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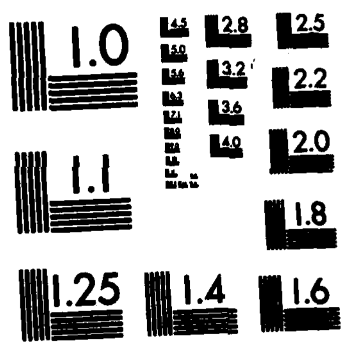

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HELICOPTER PERFORMANCE COMPUTER PROGRAMS

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Naval Air Development Center
Warminster, PA 18974

30 OCTOBER 1982

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Helicopter performance computer programs have been developed by NAVAIRDEVCEN. Performance items considered are specific excess power, sustained and instantaneous turn rate, and maneuver capability. Performance output can be displayed graphically as well as numerically.

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SUMMARY

The Naval Air Development Center (NAVAIRDEVCEN) is supporting the Naval Air Systems Command (NAVAIR) (AIR-5301) in the development of computer aided tactical performance plots for inclusion in Navy and Marine Helo Tactical Manuals. As part of this effort, computer programs ~~have been developed~~ which are capable of analyzing the flight performance of typical helicopter configurations. Areas of flight performance include specific excess power, sustained and instantaneous turn rate, and maneuver capability. ...which can be displayed as well as numerically.

These programs were written in FORTRAN and use three supporting subroutines. This report describes the analytical development and logic development for the programs. In addition, it includes a user description and complete listing.

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LIST OF SYMBOLS

Symbol	Description
A_{DISK}	Rotor disk area (ft^2)
C_p	Power coefficient
C_T	Thrust coefficient
C_{T_0}	Thrust coefficient at one g
F equiv.	Equivalent flat plate area (ft^2)
g	Acceleration due to gravity (32.1741 ft/sec^2)
h	Altitude (ft)
N_r	Rotor shaft rotation rate (revolution per minute)
n	Load factor (g's)
Q	Torque ($ft\text{-}lb_f$)
R	Radius of turn (ft)
SHP	Shaft Horsepower
T	Ambient Temperature (degrees C)
V	True Airspeed (ft/sec)
V_{CAS}	Calibrated Airspeed (ft/sec)
V_{TIP}	Rotor tip speed (ft/sec)
W	Helicopter gross weight (lb)
Δ	Increment
η_c	Empirical climb factor
η_m	Mechanical efficiency
η_p	Propulsive efficiency
μ	Rotor advance ratio

π	3.14159
ρ	Atmospheric density (slugs/ft^3)
σ	Blade solidity
σ_d	Atmospheric density ratio
$\dot{\psi}$	Turn rate (deg/sec)

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INTRODUCTION

In support of the tactical manual effort sponsored by the Naval Air Systems Command (AIR-5301), a methodology for predicting selected helicopter performance capability was developed by the Naval Air Development Center (6051). Performance items considered include specific excess power, sustained and instantaneous turn rate, and maneuver capability.

The programs discussed in this report utilize power required and power available tabular input along with other geometric and physical scalar input (e.g., rotor disk area and tip speed) to compute performance by means of the appropriate equation of motion. The output may be directly presented in numerical form; if desired, tactical manual plots can be created by the use of available plotting software.

DISCUSSION

THEORETICAL DEVELOPMENT

The computer programs described in this report provide a rapid, flexible and accurate means to generate tabular and graphical data expressing several important parameters which measure helicopter performance capability. The programs accept a common input format by which any conventional helicopter can be fully described through scalar namelist parameters and tabular data of power available and nondimensional power required. The programs exist as four separate routines which calculate performance data as follows:

Program #1: PSHELO - specific excess power as a function of load factor, calibrated airspeed and altitude

Program #2: SUSTURN - maximum sustained turn rate as a function of calibrated airspeed and altitude

Program #3: INSTURN - maximum instantaneous turn rate as a function of calibrated airspeed and altitude

Program #4: MANEUV - specific excess power, load factor and turn radius as a function of ambient condition, calibrated airspeed and altitude

A derivation and description of the equations used in each of the four routines follows.

SPECIFIC EXCESS POWER

Specific excess power (P_S) is intended as a measurement criterion for comparing relative performance capability throughout the speed-altitude envelope for any two helicopters. It is specifically a measure of the power available for maneuvering over and above that used to maintain level flight and can be expressed as shown in equation (1).

$$P_S = \frac{(P_{\text{supplied by engine}} - P_{\text{required}})}{\text{Gross Weight}} \text{ (ft/min)} \qquad (1)$$

In relating the quantity P_S to performance, the specific energy is first derived from the total energy at a point in velocity-altitude space, equation (2).

$$E = GWh + \frac{GW\,V^2}{2g} + \frac{I\Omega^2}{2} \qquad (2)$$

The specific energy or energy height is then:

$$h_e = \frac{E}{GW} = h + \frac{V^2}{2g} + \frac{I\Omega^2}{2GW} \qquad (3)$$

Specific excess power is the time rate of change of specific energy, which yields equation (4).

$$P_S = \frac{dh}{dt} + \frac{V}{g}\frac{dV}{dt} + \frac{I\Omega}{GW}\frac{d}{dt} \qquad (4)$$

where

E = total energy
h = altitude
h_e = specific energy or energy height
t = time
V = true airspeed
g = acceleration of gravity
I = rotor inertia
Ω = rotor rotational speed
GW = helicopter gross weight

The above equations reveal that a given P_S increment may contribute to a rate of climb $(\frac{dh}{dt})$, level flight acceleration $(\frac{V}{g}\frac{dV}{dt})$, an increase in rotor speed $(\frac{I\Omega}{GW}\frac{d\Omega}{dt})$ or a change in the direction of the flight path. The units of P_S are distance/time, which for helicopter applications is best suited by feet/minute.

The process of computing and plotting P_S as a function of airspeed and altitude for each helicopter was based on determining power available, subtracting from it the power required at a given airspeed and altitude, and dividing by gross weight, as expressed by equation (5).

$$P_S = \frac{.875 \times (\Delta HP) \times \eta_M \times 33000}{GW} \qquad (5)$$

where

.875 = empirical climb factor
ΔHP = power available minus power required
η_M = mechanical efficiency = 0.9
33000 = 33000 foot-lbs/minute/horsepower conversion factor
GW = helicopter gross weight

P_S yields accurate values for the rate of climb for speeds above approximately 60 knots; however, for speeds below 60 knots, the actual rate of climb is somewhat greater than the computed P_S value. This is not reflected in the equation because of the use of a constant as opposed to a variable empirical climb factor.

The computational process is carried out using nondimensional forms of power required and power available. Nondimensional power required, or power coefficient (C_P) is found as a function of thrust coefficient (C_T) and advance ratio (μ) for most existing helicopters. Thrust coefficient and advance ratio are defined by the following two expressions:

$$C_T = \frac{n_{GW}}{\rho_A V_{TIP}^2}, \text{ and } \mu = \frac{(1.689)V_T}{V_{TIP}} \tag{6}$$

where

n = load factor (g)

A = rotor disk area (ft^2)

V_{TIP} = rotor tip speed (ft/second)

V_T = true airspeed (knots)

(also, C_{T_o} is defined as C_T when $n = 1.0g$)

Engine power available at IRP is given as a function of outside air temperature (OAT) and altitude. Power is nondimensionalized using equation (7)

$$C_P = \frac{SHP \times 550}{\rho_A V_{TIP}^3} \tag{7}$$

where SHP can be either power required or power available. P_S, based on the nondimensional coefficients $C_{P_{Req}}$, $C_{P_{Avail}}$ and C_{T_o} is then found from equation (8).

$$P_S = \frac{.875 \times (C_{P_{avail}} - C_{P_{req}}) \times 60 \times \eta_M \times V_{TIP}}{C_{T_o}} = \frac{47.25 \times \Delta C_P \times V_{TIP}}{C_{T_o}} \tag{8}$$

To further explain the procedure by which P_S is calculated, we begin by determining the power available for a given flight condition (airspeed, altitude). Shaft horsepower available can be input as a function of altitude and ambient temperature, expressed by equation (9).

$$SHP = f(h,T), \tag{9}$$

or as a function of ambient temperature and altitude:

$$SHP = f(T,h) \tag{10}$$

or the percent torque available may be supplied, where shaft horsepower is the percent torque times shaft horsepower at 100% torque. If the power available data supplies percent torque, a factor for horsepower per percent of torque (FORTRAN name TORFAC) and a maximum torque limit (FORTRAN name XMSN) if other than 100% must be input. The relationship of TORFAC and XMSN is such that TORFAC times XMSN yields the transmission limit in shaft horsepower. If the transmission limit is known, this may be input (FORTRAN name PLIMIT).

A velocity correction in the power available due to ram effects may be applied. The correction can be linear:

$$SHP = SHP \times C_1 \times V_T \tag{11}$$

or exponential,

$$SHP = SHP \times C_2 \times e^{(C_3 \times V_T)} \tag{12}$$

where C_1, C_2 and C_3 are input constants (FORTRAN names DELHP, TMAN, TCHAR). The resulting shaft horsepower available is converted to coefficient form incorporating the effect of altitude through the factor ρ, air density, in equation (13).

$$C_{P_{avail}} = \frac{SHP \times 550}{\rho A V_{TIP}^3} \tag{13}$$

The next major step is to determine the power required. This is found in coefficient form as a function of either advance ratio and thrust coefficient:

$$C_{P_{req}} = f(\mu, C_T) \tag{14}$$

or as a function of thrust coefficient and advance ratio:

$$C_{P_{req}} = f(C_T, \mu). \tag{15}$$

If $C_{P_{req}} = f(\mu, C_T)$, then an input switch (FORTRAN name MUCTSW) is set equal to 1, and if $C_{P_{req}} = f(C_T, \mu)$, the switch is set equal to 0. Recalling that P_S is presented as a function of airspeed and altitude, at this point it is noted that advance ratio is a function of speed, and C_T is a function of density ρ which incorporates the effect of altitude. Hence, we can represent this dependence as follows:

$$\left.\begin{array}{r}\mu = f(V_T)\\ C_T = f(h)\end{array}\right\} C_P = f(\mu, C_T) \rightarrow P_S = f(C_P, C_T) \rightarrow P_S = f(V_T, h) \qquad (16)$$

arriving at the final result of specific excess power as a function of airspeed and altitude which is ultimately plotted.

An incremental drag correction can be made to the power required coefficient using an incremental equivalent flat plate area in the last term in equation (17).

$$C_{P_{req}} = C_{P_{req}} + \frac{\Delta F_e \times \mu^3}{2 \times A \times \eta_M \times \eta_P} \qquad (17)$$

Acceptable values for mechanical efficiency, η_M (FORTRAN name ETAM) and propulsive efficiency, η_P (FORTRAN name ETAP) are 0.9 and 0.8, respectively. Incremental flat plate area (FORTRAN name DELFE) is used to adjust helicopter drag for variations in weapons loadings.

Specific excess power performance plots can be generated for various load factors. This is done by inputting the desired load factor, n (FORTRAN name GFAC) which is then used in the calculation of the thrust coefficient, C_T.

SUSTAINED TURN RATE

The equation used to compute turn rate is based on the point mass equation, and is a function of load factor, airspeed, and flight path angle, as expressed in equation (18).

$$\dot{\psi} = \frac{g\sqrt{n^2 - \cos^2\gamma}}{V \cos \gamma} \tag{18}$$

where

$\dot{\psi}$ = turn rate (radians/second)

n = load factor (g)

γ = flight path angle (radians)

V = true airspeed (feet/second)

Using the small angle assumption that $\gamma = 0$, the following classical relationship results in equation (19).

$$\dot{\psi} = \frac{g\sqrt{n^2 - 1}}{V} \tag{19}$$

Computations require that $\dot{\psi}$ be in units of degrees/second, and V in knots. With appropriate conversion factors inserted, the turn rate equation becomes that shown in equation (20).

$$\dot{\psi} = \frac{32.17 \times \sqrt{n^2-1}}{V_T\ (1.689)} \times \left(\frac{180}{\pi}\right) = 1091.4388 \times \frac{\sqrt{n^2-1}}{V_T} \tag{20}$$

where V_T = true airspeed in knots.

To arrive at maximum sustained turn rate at any point within the flight envelope, power required is set equal to power available:

$$C_{P_{req}} = C_{P_{avail}}$$

Having $C_{P_{req}}$ and the advance ratio μ for a given airspeed, the thrust coefficient C_T is read from the input helicopter performance data, as expressed by equation (20).

$$C_T = f(C_P, \mu) \tag{20}$$

The sustained load factor is the thrust divided by the weight, equation (21).

$$n = \frac{C_T \times \rho \times A \times V_{TIP}^2}{GW} \tag{21}$$

Finally, the sustained turn rate for a given airspeed and altitude using the sustained load factor is found from the turn rate equation (20).

MAXIMUM INSTANTANEOUS TURN RATE

Maximum instantaneous turn rate is derived from the maximum amount of thrust which the rotor system can attain on a transient or nonsustained basis. Maximum thrust (or rotor limit) for a given helicopter can be expressed by the quantity in equation (22).

$$\frac{2\,C_{T_{max}}}{\sigma} = f(\mu) \tag{22}$$

where

$C_{T_{max}}$ = maximum thrust coefficient

σ = rotor solidity = $\frac{bc}{\pi R}$

b = number of blades

bx

c = blade chord

R = rotor radius

This quantity is approximate since blade stall is gradual, and its occurrence is affected by the direction of turn as well as airspeed. The program INSTURN requires $C_{T_{max}}$ (FORTRAN name CTMAX) to be input, where $C_{T_{max}}$ is either known explicitly or can be solved for from the expression $\frac{2\,C_{T_{max}}}{\sigma}$. Either $C_{T_{max}}$ or $\frac{2\,C_{T_{max}}}{\sigma}$ are known or estimated for most existing helicopters.

Having $C_{T_{max}}$ and using the following relation in equation (23),

$$n = \frac{\rho \; A \; V_{TIP}^{2} \; C_{T_{max}}}{GW} \tag{23}$$

the maximum instantaneous load factor is computed at any point in the flight envelope. The final step yields the turn rate as a function of true airspeed and load factor (which incorporates the effect of altitude using ρ) using the turn rate equation (20) derived in the section on sustained turn rate.

As airspeed approaches zero, turn rate values become unrealistically large. It becomes necessary to specify a maximum turn rate attainable at zero airspeed in degrees per second (FORTRAN name TRVØ), either due to control limitations, a handling qualities limit determined in testing, some value based on vehicle similarities or other reasonable assumptions. A second value required to define the maximum instantaneous turn rate versus airspeed curve is the break velocity (FORTRAN name VB). The break velocity, usually between 50 and 80 knots, is the lowest airspeed for which the instantaneous turn rate is calculated. Below the break velocity, an internal curve-fitting routine blends the calculated turn rate curve from the break velocity to the maximum instantaneous turn rate value (TRVØ) at zero airspeed.

MANEUVER CAPABILITY

Two previous programs computed specific excess power (P_S) at selected load factors and maximum sustained turn rate over the helicopter's entire airspeed-altitude envelope. By introducing the parameters P_S and turn rate into one graph at one ambient condition (fixed altitude and temperature), the resultant capability for a specified airspeed and selected turn radius can be shown. The maneuver capability graph is plotted against calibrated airspeed in knots and turn rate in degrees per second.

Lines of constant radius for 500, 1000, 1500 and 2000 feet are projected on the airspeed-turn rate graph according to the geometrical relation, equation (24).

$$\dot{\psi} = \frac{V}{R} \tag{24}$$

For R in feet, V_T in knots true airspeed and $\dot{\psi}$ in degrees per second, the relation becomes that shown in equation (25).

$$\dot{\psi} = 96.7726 \times \frac{V_T}{R} \tag{25}$$

and for calibrated airspeed in knots, V_T is replaced by $V_c/\sqrt{\sigma_d}$ where σ_d is the density ratio at the selected ambient condition so that the final expression equation (26) is

$$\dot{\psi} = 96.7726 \times \frac{V_C}{R\sqrt{\sigma_d}} \tag{26}$$

Lines of constant load factor are plotted against airspeed and turn rate, and also result from the geometrical relation of equation (20).

$$\dot{\psi} = \frac{g\sqrt{n^2-1}}{V} = 1091.4388 \times \frac{\sqrt{n^2-1}}{V_T} \text{ (deg/sec)} \tag{20}$$

Using calibrated airspeed, this becomes that shown in equation (27).

$$\dot{\psi} = 1091.4388 \times \frac{\sqrt{\sigma_d}\sqrt{n^2-1}}{V_C} \text{ (deg/sec)} \tag{27}$$

Superimposed over turn radius and load factor lines are the specific excess power curves of a particular helicopter. The construction of these curves begins with expressing load factor as a function of turn rate, as shown in equation (28).

$$n = \sqrt{\left(\frac{\dot{\psi}V}{g}\right)^2 + 1} \tag{28}$$

This defines a load factor for each value of turn rate and airspeed. This load factor defines a thrust coefficient and the airspeed defines an advance ratio which yield a power required coefficient read from the helicopter performance data. Specific excess power is determined from the power required and power available coefficients shown earlier in equation (8).

An additional line generated by the Maneuver Capability program is the rotor limit line, based on the $C_{T_{max}}$ value input for each particular helicopter. The rotor limit line is parallel to the lines of constant load factor.

The main program logic, which illustrates how the above equations are implemented, is presented in Appendix C.

PROGRAM DESCRIPTION

In addition to the main programs, which perform the computations on the dynamic equations, there are three supporting subroutines, as described below.

GREAD/TLOOK - This is a three degree-of-freedom interpolation routine and has two modes of operation. In the first mode, table data representing power required and available characteristics are input and stored. Each table is assigned a predetermined reference number. In the second mode, table data are interpolated and extrapolated by employing the function SPLINR for use in the dynamic calculations. A more detailed explanation of this routine can be found in reference (a).

SPLINR - This function is used to interpolate or extrapolate two-dimensional data. The interpolation is calculated using a local curve fit scheme described in reference (b). Linear extrapolations are made using each end point slope of the local curve fit.

ATMOS - This is an atmosphere table which returns properties of density, pressure, temperature, and sound velocity for an input altitude and atmosphere code (i.e., 1 = standard, 2 = hot day, 3 = tropical day).

The data required for the program consist of a series of single-value fixed inputs and multiple-valued tabular inputs. The form of the computer data deck necessary to make a run is presented in Figure 1.

The tabular data include:

- Power available as a function of altitude and ambient temperature (see Figure 2).

or:

- Percent torque available as a function of ambient temperature and altitude (see Figure 3).

- Power required coefficient as a function of thrust coefficient and advance ratio. This table is used in the specific excess power and maneuver programs (see Figures 4 and 5).

- Thrust coefficient as a function of power required coefficient and advance ratio. This table is used in the sustained turn rate program (see Figure 6).

It should be noted that none of the above tabular inputs are required for the instantaneous turn rate program.

The fixed inputs consist of helicopter size and mass data, ambient conditions, efficiencies, and program switches which regulate the options available to the user. Table I contains a scalar input variable list.

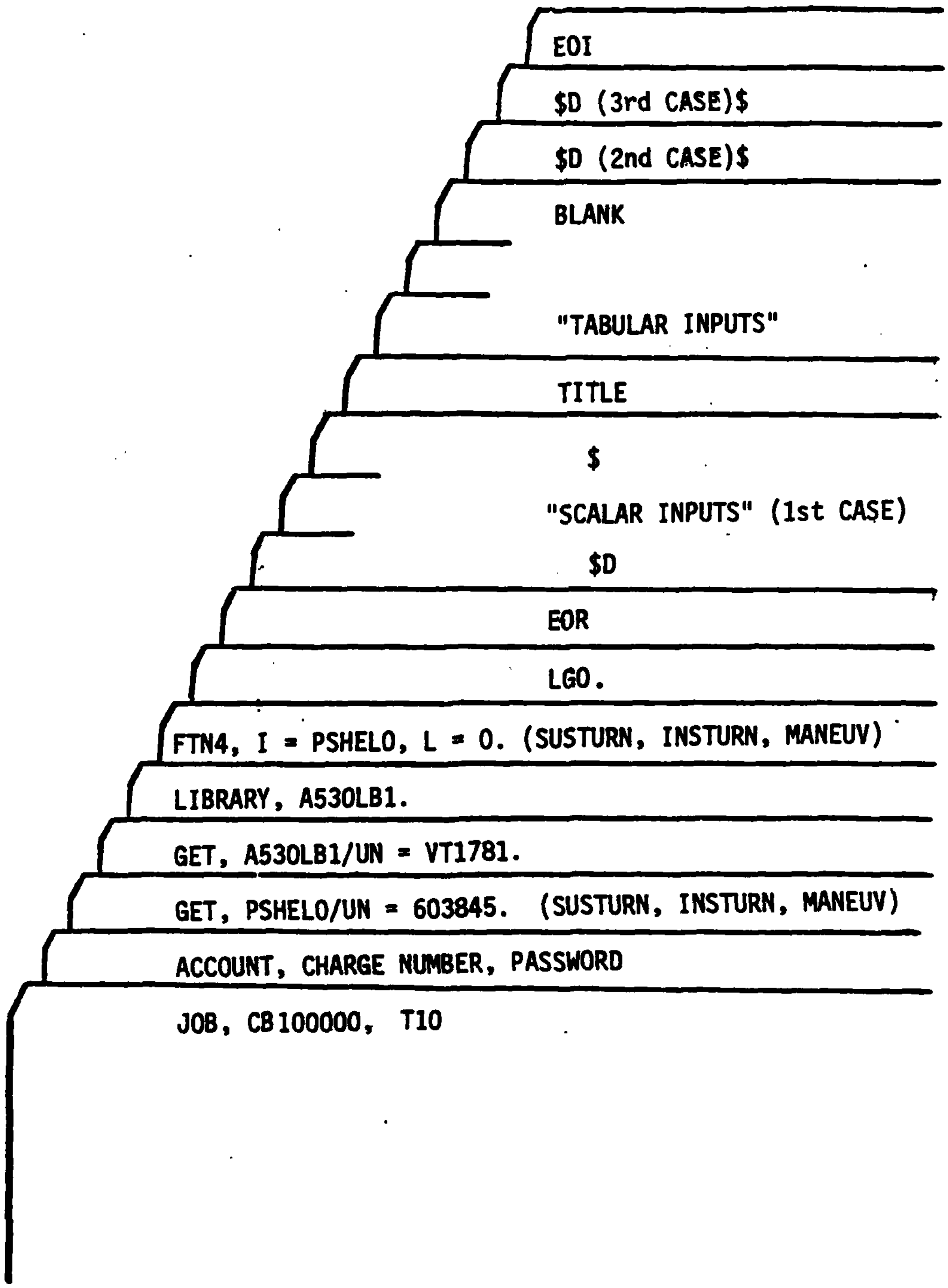

FIGURE 1. Data Input Deck Structure

Table Reference No. 10
SHP = f (h, T)

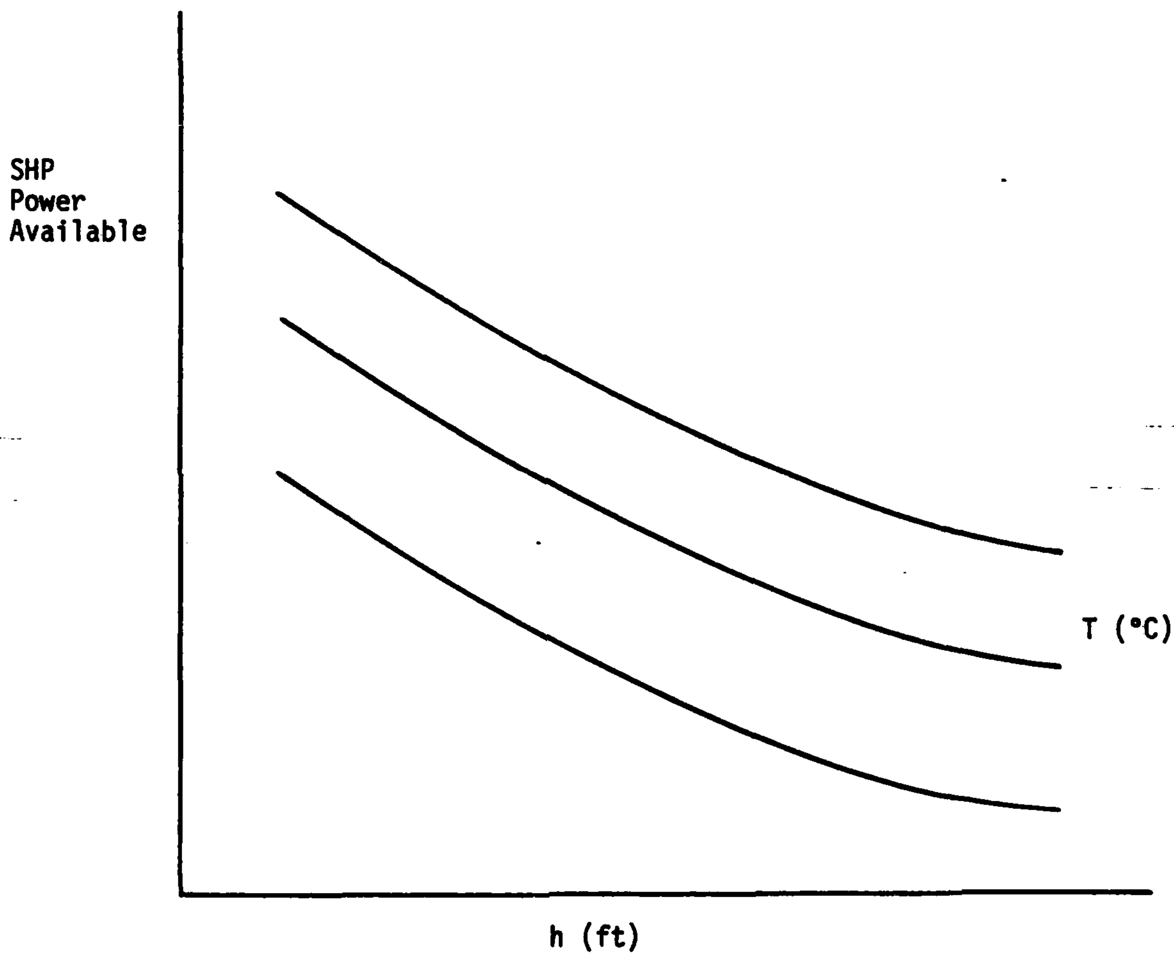

FIGURE 2. Power Available Tabular Input

Table Reference No. 10
Q = f (T, h)

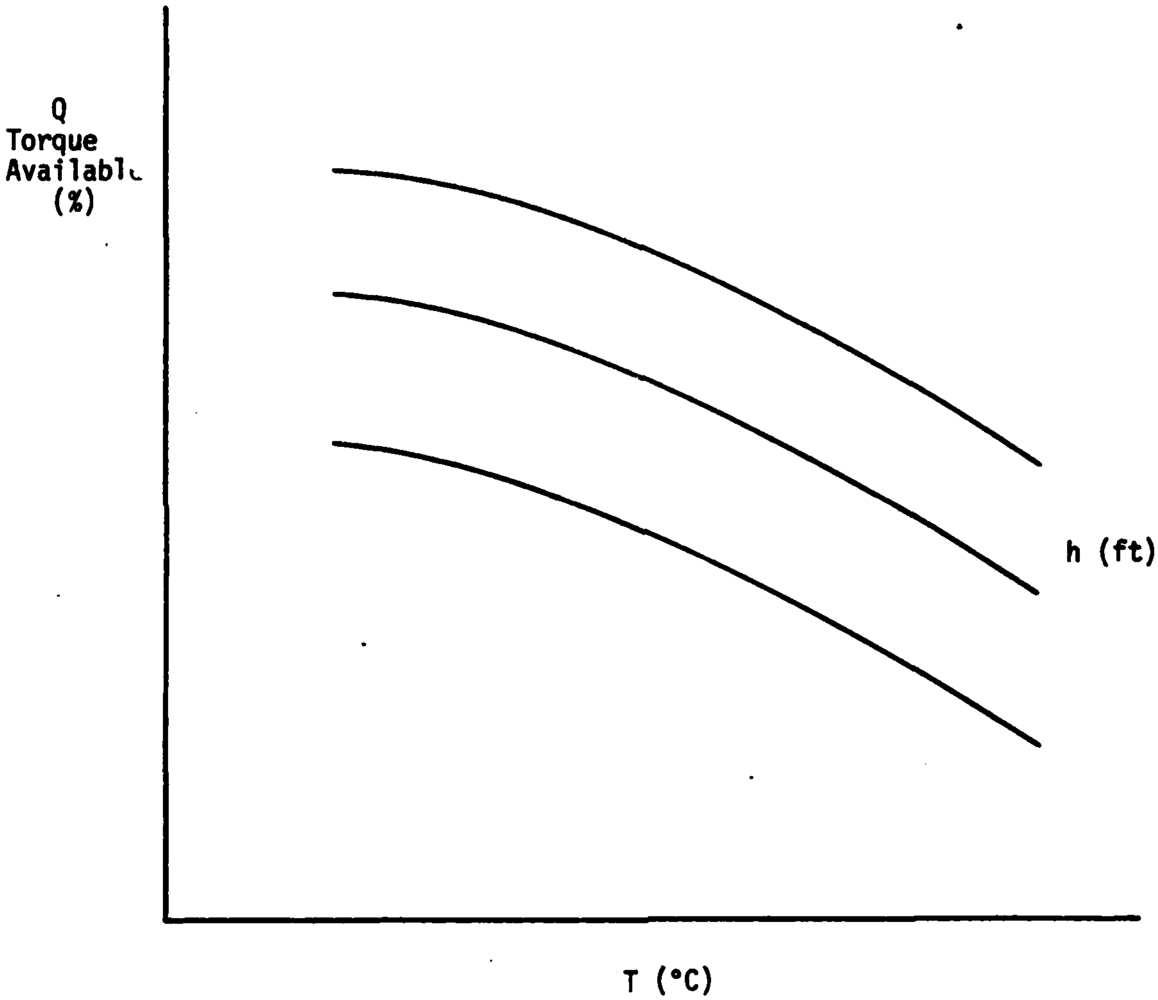

FIGURE 3. Torque Available Tabular Input

Table Reference No. 9
$C_p = f\ (C_T, \mu)$

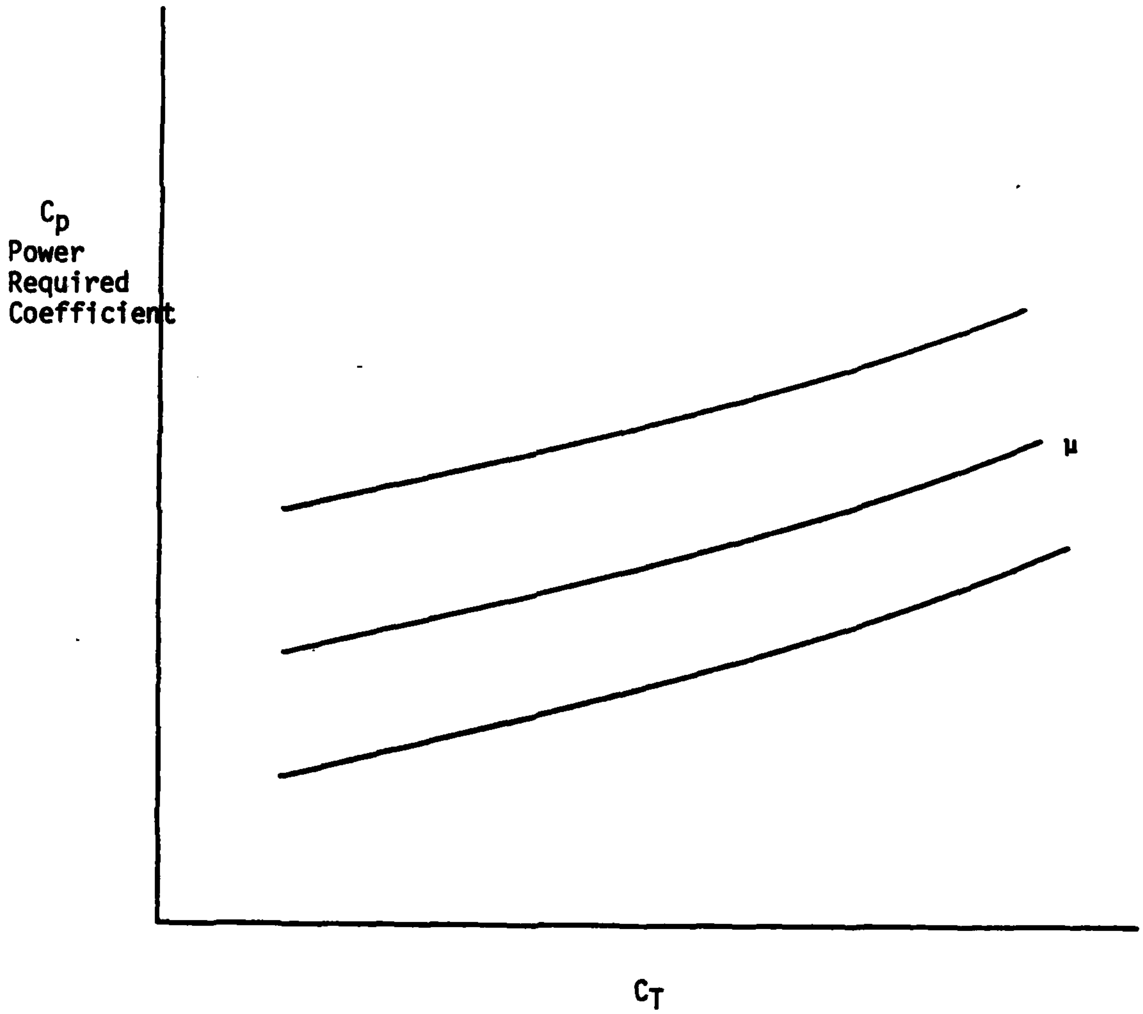

FIGURE 4. Power Required Coefficient Tabular Input, MUCTSW = 0

Table Reference No. 9
$C_p = f(\mu, C_T)$

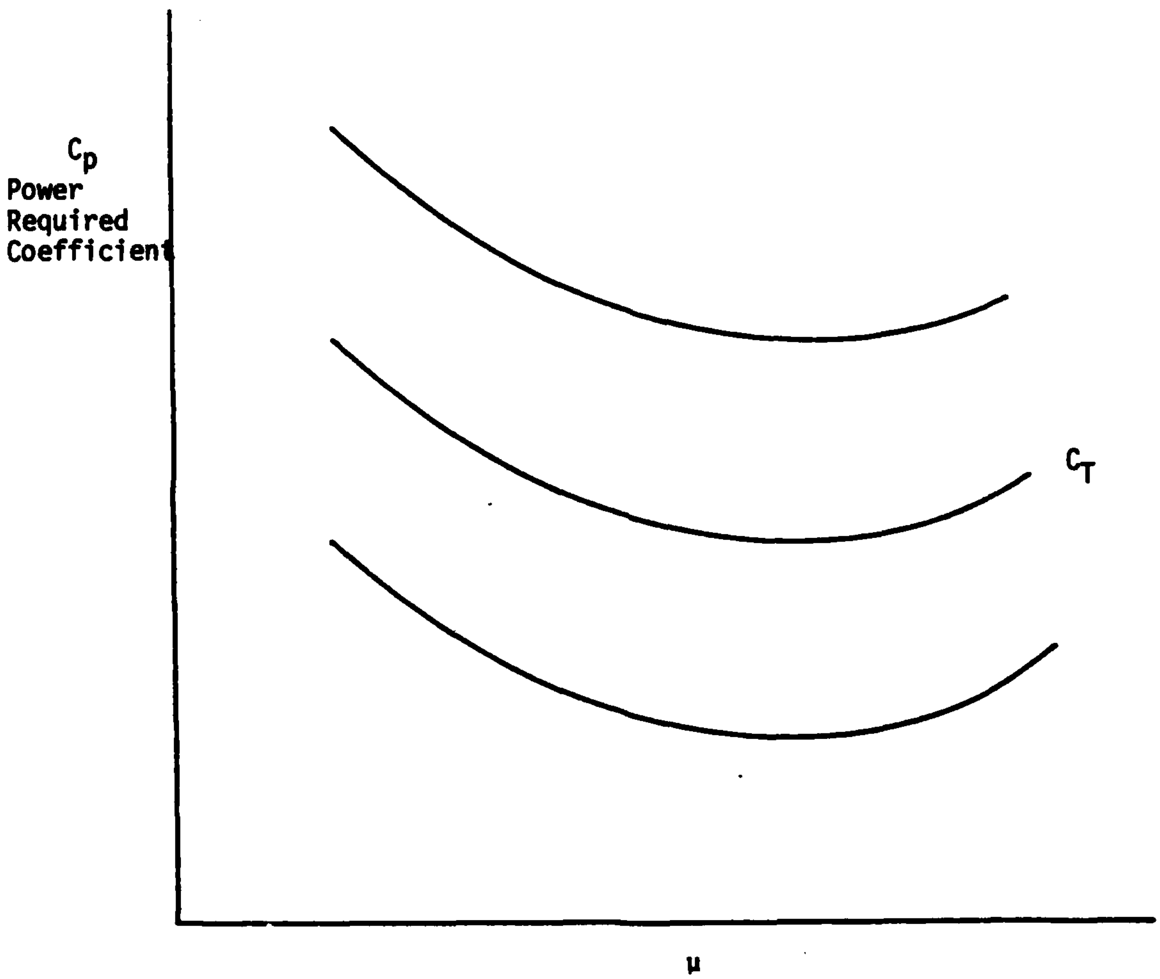

FIGURE 5. Power Required Coefficient Tabular Input, MUCTSW $\neq$ 0

Table Reference No. 11
$C_T = f\ (C_p, \mu)$

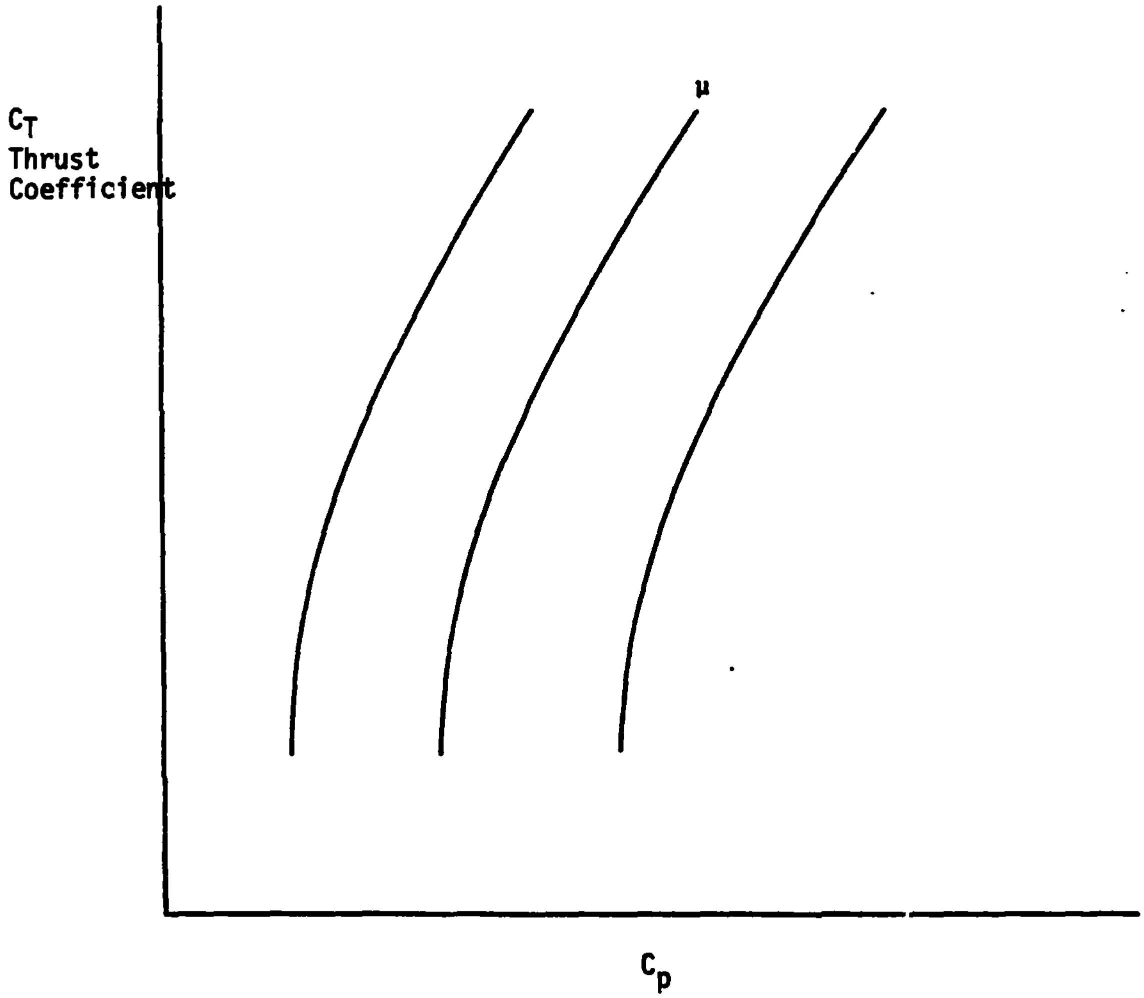

FIGURE 6. Thrust Coefficient Tabular Input

TABLE I. SCALAR INPUT VARIABLE LIST

Variable Name	Description	Units	Default Value
ADISK	Rotor Disk Area	ft^2	-
ALTØ	Maneuver Altitude	ft	0.0
ALT1	Initial Matrix Altitude	ft	0.0
CAS1	Initial Matrix Calibrated Airspeed	knots	0.0
CTMAX	Maximum Thrust Coefficient (used for instantaneous $\dot{\psi}$ and maneuver)	-	-
DELCAS	Calibrated Airspeed Matrix Increment	knots	-
DELFE	Equivalent Flat Plate Area Increment	ft^2	0.0
DELPH	Linear Velocity Correction Power Constant	SHP	0.0
DELTALT	Altitude Matrix Increment	ft	-
DELTRT	Turn Rate Matrix Increment	deg/sec	-
ETAM	Mechanical Efficiency	-	1.0
ETAP	Propulsive Efficiency	-	1.0
GFAC	Load Factor	g's	-
IPRINT	If ≠ 0, diagnostics will be printed	-	0.0
KATMOS	If ≠ 1, standard day atmospheric properties; if = 2, hot day; if =3, tropical day	-	-
MUCTSW	If = 0, $C_p = f(C_T, \mu)$ input; if ≠ 0, $C_p = f(\mu, C_T)$ input	-	0.0
NALT	Number of Matrix Altitudes	-	-
NCAS	Number of Matrix Calibrated Airspeeds	-	-
NPRINT	If ≠ 0, tabular input will be printed	-	0.0
NTRNRT	Number of Matrix Turn Rates	deg/sec	-
PLIMIT	Transmission Limit	SHP	10^6
PSIMAX	Maximum Sustained Turn Rate	deg/sec	60.
TCHAR	Exponential Velocity Correction Characteristic	-	1.0
TMAN	Exponential Velocity Correction Mantissa	-	0.0
TOGW	Helicopter Weight	lb.	-
TORFAC	Torque Scale Factor; if = 0, power available input	$ft\text{-}lb_f$	0.0
TRVØ	Maximum Instantaneous Turn Rate	deg/sec	-
VB	When $V_{CAS} < VB$, sustained $\dot{\psi}$ altered to satisfy PSIMAX@ $V_{CAS} = 0$	knots	-
VTIP	Rotor Tip Speed	ft/sec	-
XMSN	PLIMIT/TORFAC, used when torque is input	-	0.0

Appendix A consists of a series of example cases which show how each helicopter performance program is implemented. Reference (c) should be consulted for information concerning the generation of the tactical manual plots presented in this appendix. Appendix B contains listings of the main performance source decks.

COMPUTATIONAL PROCEDURE

Initially, default conditions are set (e.g., $\eta_M = \eta_P = 1.$, (DELHP=0.), then scalar and tabular input previously described is loaded into the programs. Scalar variables are input through the FORTRAN utility NAMELIST and the tabular data is input through the subroutine TREAD. Minimal tabular input for each program was discussed in the previous section. The inputted scalar variables override the initial default values. After the input has been stored, the programs enter an altitude DO LOOP at statement #50 which concludes at statement #100. At the beginning of this loop, altitude and temperature corrections are implemented and the input data is adjusted accordingly. Nested in the altitude loop is a velocity DO LOOP which begins at statement #60 and concludes at statement #100 (statement #101 for the instantaneous turn rate program). It is in this velocity loop that the helicopter P_S or $\dot{\psi}$ is determined for each velocity-altitude matrix condition. After the two main loops have been executed, the programs load the output matrix on a file designated as TAPE6. This data is in TPLOT format and can be directly plotted by utilizing the software described in reference (c). Finally, the output matrix is loaded on a file designated as TAPE8 in a format directly applicable to the tactical manual interface software. The instantaneous turn rate program incorporates low speed turn rate corrections to the output matrix before TAPE6 and TAPE8 files are generated. The maneuver program is similar in context to the other helicopter performance programs except that the main altitude DO LOOP is replaced by a turn rate input loop.

ACKNOWLEDGMENT

The authors wish to express appreciation to Michael Caddy who developed the interpolation and graphics software used in this analysis. Appreciation is also extended to Adam Petruszka for his technical concepts regarding helicopter theory.

REFERENCES

(a) Caddy, M. J., "TREAD/TLOOK - Multipurpose Computer Routine for Interpolation and Extrapolation of Tabular Data," NAVAIRDEVCEN Report No. NADC-76366-30 of 11 Jan 1977.

(b) Akima, Hiroshi, "Interpolation and Smooth Curve Fitting Based on Local Procedures," Institute for Telecommunications Sciences of 1 Mar 1972.

(c) Caddy, M. J., "TIGS - An Interactive Graphical System for the Creation and Correction of Tabular Data Sets," NAVAIRDEVCEN Report No. NADC-78229-60 of 5 Aug 1978.

(d) Woods, Steven A. and Kobus, David B., "The Generation of Tactical Engagement Plots for the AH-1J/T Against Various Friendly and Threat Helicopters (U)," Report No. NADC-82185-60 of 30 Jun 1982

APPENDIX A

EXAMPLE CASES

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Representative cases showing the numerical and graphical output of the specific excess power, sustained and instantaneous turn rate and maneuver programs are presented. An example input deck, which is compatible with all four performance cases, is displayed in Table AI. The table section of this sample input is graphically illustrated in Figures A-1, A-2, and A-3. Each program contains three output file units. The file unit designated as TAPE 10 contains a detailed input listing together with the output diagnostics (if selected by the IPRINT and NPRINT options). The file unit designated as TAPE 6 contains tabulated output in a format directly usable to the graphics package described in reference (c). The file unit designated as TAPE 8 contains the tabulated matrix output which forms the basis of the tactical manual plots. TAPE 8 data has to be transmuted by preprocessing software before the graphics routines of reference (c) can be applied to create the tactical manual plots. The nature of this intermediate software will be discussed in a future publication. The remaining figures and tables in this appendix present examples of some of these output files for each performance program along with a sample tactical manual plot. In addition to the above output, the specific excess power program creates a file unit designated as TAPE 3 which contains the flight envelope data displayed in the instantaneous turn rate tactical manual plot. Finally, the capability to portray comparative plots between two separate helicopters is available in the previously mentioned intermediate software.

Reference (d) should be consulted for tactical manual applications involving existing helicopter weapon systems.

```
$D NCAS=21,NALT=21,CAS1=1,ALT1=0,DELTALT=1000,
   UTIP=750,KATMOS=1,GFAC=1,TOGW=12500,DELCAS=10,
   ADISK=2000,PLIMIT=2300,CTMAX=.015,VB=80,
   TRV0=60,NTRNRT=30,DELTRT=2,ALT0=0,
   IPRINT=1,NPRINT=0,
$
   EXAMPLE INPUT
  10    EXAMPLE POWER=F(H,T)
Z     1   0.
T     3   -50.       0.         50.
ALT   3   0.         10000.     20000.
POWR  3   2500.      2000.      1500.
POWR  3   2000.      1500.      1000.
POWR  3   1500.      1000.      500.
EOT
   9    EXAMPLE CP=F(CT,MU)
Z     1   0.
MU    3   0.         .25        .50
CT    3   .001       .005       .01
CP    3   .0003      .0005      .0020
CP    3   .0001      .0002      .0010
CP    3   .0005      .0008      .0030
EOT
  11    EXAMPLE CT=F(CP,MU)
Z     1   0.
MU    3   0.         .25        .50
CP    4   .0003      .0005      .001245    .0020
CT    4   .001       .005       .008       .01
CP    4   .0001      .0002      .000595    .0010
CT    4   .001       .005       .008       .01
CP    4   .0005      .0008      .0019      .0030
CT    4   .001       .005       .008       .01
EOT
\?
```

Table A1. Sample Data Input

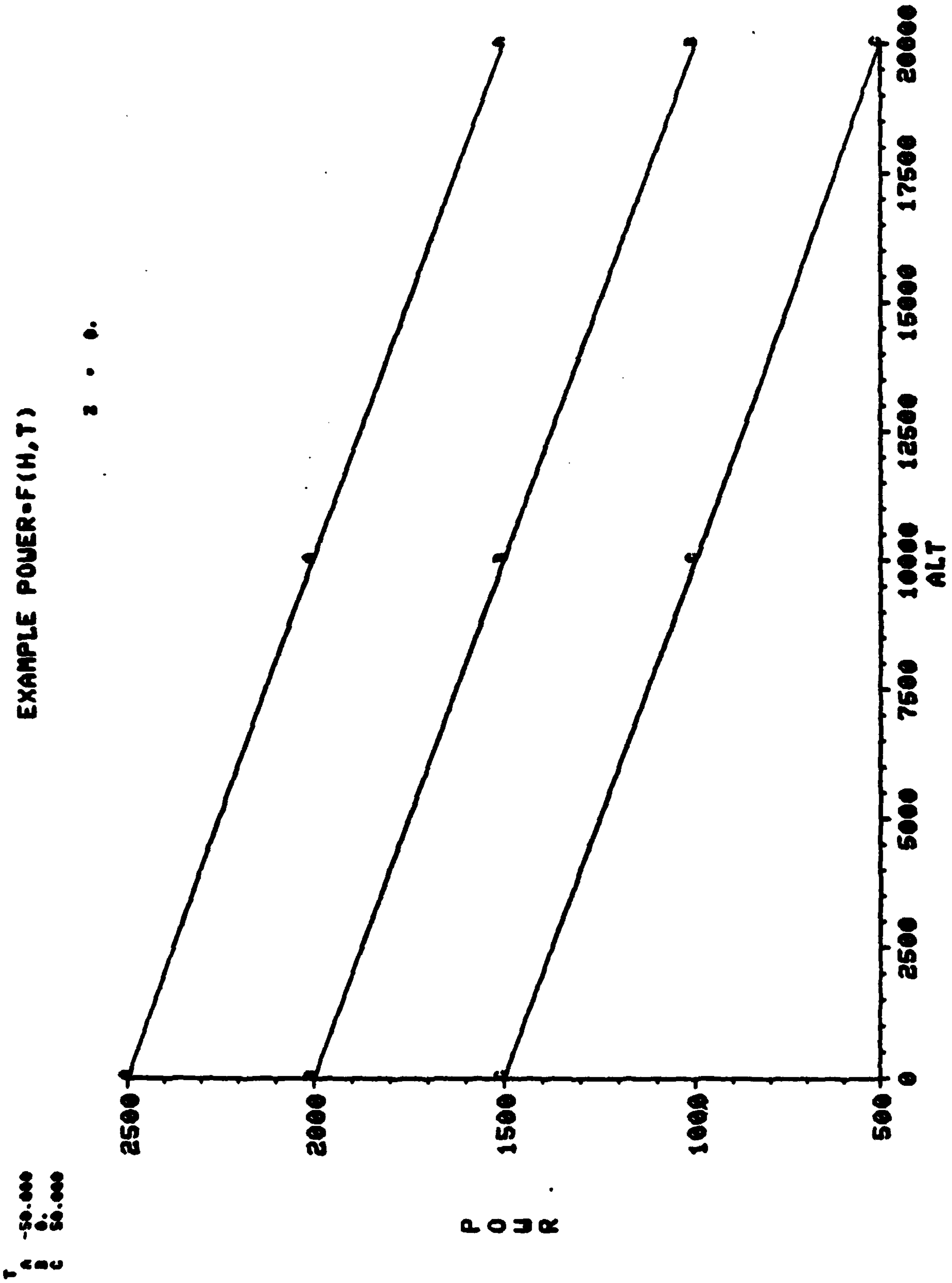

FIGURE A1. Sample SHP Input (Graphical)

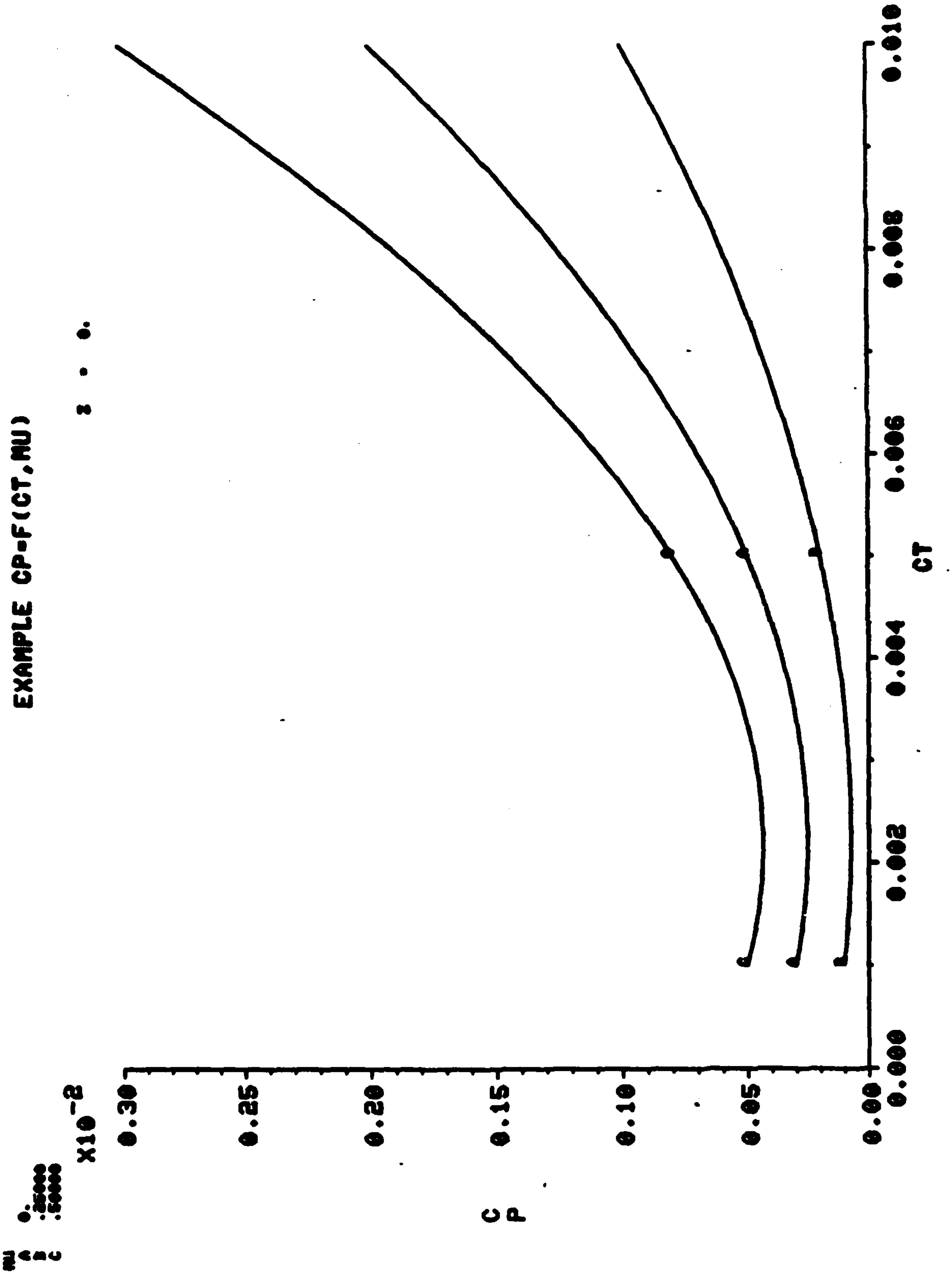

FIGURE A2. Sample C_p Input (Graphical)

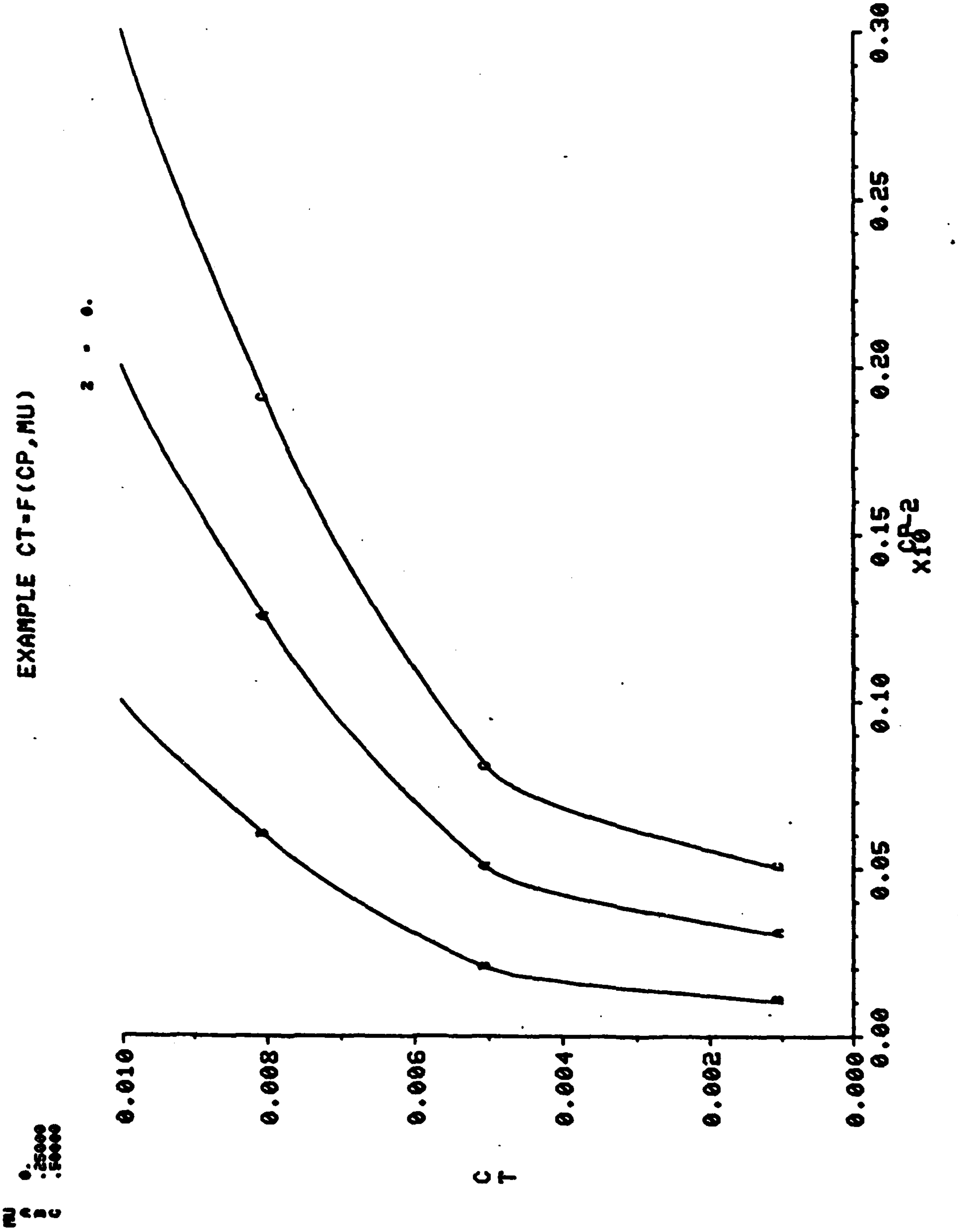

FIGURE A3. Sample C_T Input (Graphical)

APS0101 EXAMPLE INPUT
21 21 1. 10. 0. 1000. 0

VEL/ALT	0.	1000.	2000.	3000.	4000.	5000.	6000.	7000.	8000.
0.	462.34	334.43	198.82	55.797	-93.482	-249.14	-411.40	-580.49	-756.66
10.000	906.83	787.83	663.10	532.02	395.70	254.04	106.89	-45.906	-204.53
20.000	1296.8	1196.6	1072.6	951.21	825.36	695.00	560.05	420.39	275.91
30.000	1641.0	1536.8	1427.4	1313.4	1195.5	1073.7	948.06	818.42	684.65
40.000	1932.5	1832.3	1727.5	1618.5	1506.1	1390.3	1271.0	1148.2	1021.7
50.000	2173.4	2075.2	1972.9	1866.6	1757.2	1644.6	1528.8	1409.6	1287.1
60.000	2363.5	2265.5	2163.5	2057.6	1948.7	1836.7	1721.4	1602.8	1480.8
70.000	2503.0	2403.2	2299.3	2191.6	2080.7	1966.5	1848.9	1727.7	1602.8
80.000	2591.7	2488.2	2380.5	2268.6	2153.2	2034.2	1911.3	1784.3	1653.1
90.000	2629.2	2520.6	2406.9	2288.6	2166.2	2039.6	1908.5	1772.7	1631.7
100.00	2617.2	2500.4	2378.5	2251.5	2119.7	1982.8	1840.7	1692.7	1538.6
110.00	2563.9	2427.6	2296.5	2157.4	2013.6	1863.8	1707.6	1544.5	1373.9
120.00	2439.9	2302.2	2157.7	2006.2	1848.0	1682.6	1509.5	1328.0	1137.4
130.00	2275.2	2124.1	1965.2	1798.0	1622.9	1439.2	1246.2	1043.2	829.27
140.00	2069.8	1893.4	1717.9	1532.8	1338.2	1133.5	917.84	690.16	449.45
150.00	1793.7	1610.1	1415.9	1210.5	994.05	765.67	524.31	268.82	-2.0623
160.00	1477.0	1274.2	1060.2	831.20	590.36	335.58	65.649	-220.80	-525.86
170.00	1100.5	885.37	647.71	394.86	187.13	-156.72	-458.14	-778.70	-1120.2
180.00	651.30	444.50	181.61	-98.506	-395.61	-711.24	-1047.1	-1404.9	-1786.7
190.00	222.56	-40.284	-339.42	-648.91	-977.89	-1328.0	-1701.1	-2099.3	-2525.0
200.00	-296.96	-595.69	-915.08	-1256.4	-1619.7	-2006.9	-2420.3	-2862.1	-3331.4

VEL/ALT	9000.	10000.	11000.	12000.	13000.	14000.	15000.	16000.	17000.
0.	-940.15	-1131.3	-1330.3	-1537.6	-1753.2	-1977.8	-2211.6	-2455.1	-2708.6
10.000	-300.16	-530.98	-717.20	-901.04	-1091.7	-1289.5	-1494.5	-1707.2	-1927.7
20.000	126.46	-28.073	-187.24	-362.99	-523.67	-700.05	-882.29	-1070.6	-1265.1
30.000	546.70	404.47	257.83	106.70	-49.054	-209.55	-374.92	-545.29	-720.82
40.000	891.57	757.64	619.82	478.08	332.13	182.03	27.598	-131.31	-294.83
50.000	1161.1	1031.4	898.12	760.98	619.88	474.69	325.24	171.36	12.871
60.000	1356.2	1226.9	1098.7	955.57	814.20	668.42	518.01	362.72	202.27
70.000	1473.9	1341.0	1203.7	1061.8	915.09	763.24	605.92	442.77	273.36
80.000	1517.3	1378.7	1230.9	1079.7	922.55	759.14	588.97	411.50	226.16
90.000	1485.3	1333.0	1174.4	1009.2	836.57	656.12	467.15	268.93	60.649
100.00	1377.9	1210.0	1034.3	850.28	657.17	454.19	240.46	15.030	-223.16
110.00	1195.1	1007.6	810.48	603.06	384.33	153.33	-91.088	-350.18	-625.27
120.00	936.96	725.79	502.97	267.46	18.066	-246.45	-527.51	-826.67	-1145.7
130.00	603.44	364.66	111.77	-156.52	-441.63	-745.14	-1068.8	-1414.5	-1784.4
140.00	194.55	-75.830	-363.12	-668.85	-994.76	-1342.8	-1714.9	-2113.6	-2541.4
150.00	-289.73	-596.70	-921.00	-1269.5	-1641.3	-2039.3	-2466.0	-2924.1	-3416.7
160.00	-849.37	-1194.9	-1564.0	-1958.8	-2301.3	-2834.7	-3321.8	-3845.8	-4410.3
170.00	-1484.4	-1873.5	-2289.9	-2736.0	-3214.7	-3720.1	-4282.6	-4878.9	-5522.2
180.00	-2194.8	-2631.5	-3098.5	-3601.8	-4141.6	-4721.9	-5340.3	-5998.0	-6698.2
190.00	-2980.6	-3468.8	-3990.9	-4544.3	-5131.3	-5754.8	-6417.7	-7123.0	-7874.3
200.00	-3827.3	-4351.9	-4907.7	-5487.1	-6128.8	-6787.7	-7405.0	-8248.0	-9060.3

VEL/ALT	18000.	19000.	20000.
0.	-2972.6	-3247.5	-3633.8
10.000	-2156.4	-2393.6	-2630.5
20.000	-1466.1	-1673.7	-1888.2
30.000	-901.06	-1088.0	-1279.9
40.000	-463.11	-636.33	-814.67
50.000	-150.44	-318.80	-492.46
60.000	36.347	-136.38	-313.28
70.000	97.253	-86.061	-277.14
80.000	32.878	-170.86	-384.03
90.000	-158.58	-380.75	-633.96
100.00	-475.32	-742.75	-1026.9
110.00	-917.83	-1229.9	-1562.9
120.00	-1406.4	-1851.1	-2241.8

Table AII. Sample TAPE8 Matrix Output (Abbreviated)

```
 10    EXAMPLE POWER=F(H,T)
  9   EXAMPLE CP=F(CT,MU)
 11   EXAMPLE CT=F(CP,MU)
                              TABLE DATA INPUT SUMMARY  3 TABLES

                        TABLE NUMBER  REFERENCE NUMBER   ARRAY LOCATION
                              1              9.                115.
                              2             10.                 61.
                              3             11.                160.

                              DATA STORAGE ALLOCATION 3000
                              DATA STORAGE NOT USED   2777
100
0NCAS     = 21,
0NALT     = 21,
0DELCAS   = .1E+02,
0DELTALT  = .1E+04,
0IATYPE   = 0,
0CPINP    = 0.0,
0VTIP     = .75E+03,
0UNU      = 0.0,
0CAS1     = .1E+01,
0ALT1     = 0.0,
0CTUAL    = 0.0,
0KATMOS   = 1,
0GFAC     = .1E+01,
0TOGW     = .125E+05,
0ADISK    = .2E+04,
0TORFAC   = 0.0,
0PLIMIT   = .23E+04,
0ETAM     = .1E+01,
0ETAP     = .1E+01,
0DELFE    = 0.0,
0NPRINT   = 0,
0THAN     = 0.0,
0TCHAR    = .1E+01,
0NUCTSU   = 0,
0XMSH     = .1E+03,
0IPRINT   = 1,
0DELHP    = 0.0,
0CTMAX    = .15E-01,
0TRVO     = 0.0,
0VB       = .8E+02,
0NTRMRT   = 30,
0DELTRT   = .2E+01,
0ALTO     = 0.0,
0PSIMAX   = .6E+02,
0END
 PS,G,MU,V,ALT,CT,CPI,RHO,CPR
    *****   462.34     1.0000    0.            0.        0.        .46746E-02  .50736E-03  .23768E-02  .44637E-03
    *****   905.93     1.0000    .22520E-01   10.000     0.        .46746E-02  .50736E-03  .23768E-02  .38785E-03
    *****   1298.8     1.0000    .45040E-01   20.000     0.        .46746E-02  .50736E-03  .23768E-02  .33603E-03
    *****   1641.0     1.0000    .67560E-01   30.000     0.        .46746E-02  .50736E-03  .23768E-02  .29008E-03
    *****   1932.5     1.0000    .90080E-01   40.000     0.        .46746E-02  .50736E-03  .23768E-02  .25243E-03
    *****   2173.4     1.0000    .11260       50.000     0.        .46746E-02  .50736E-03  .23768E-02  .22066E-03
    *****   2363.5     1.0000    .13512       60.000     0.        .46746E-02  .50736E-03  .23768E-02  .19658E-03
    *****   2503.0     1.0000    .15764       70.000     0.        .46746E-02  .50736E-03  .23768E-02  .17718E-03
    *****   2591.7     1.0000    .18016       80.000     0.        .46746E-02  .50736E-03  .23768E-02  .16540E-03
\7
```

Table AIII. Sample TAPE10 Diagnostic Output (Abbreviated)

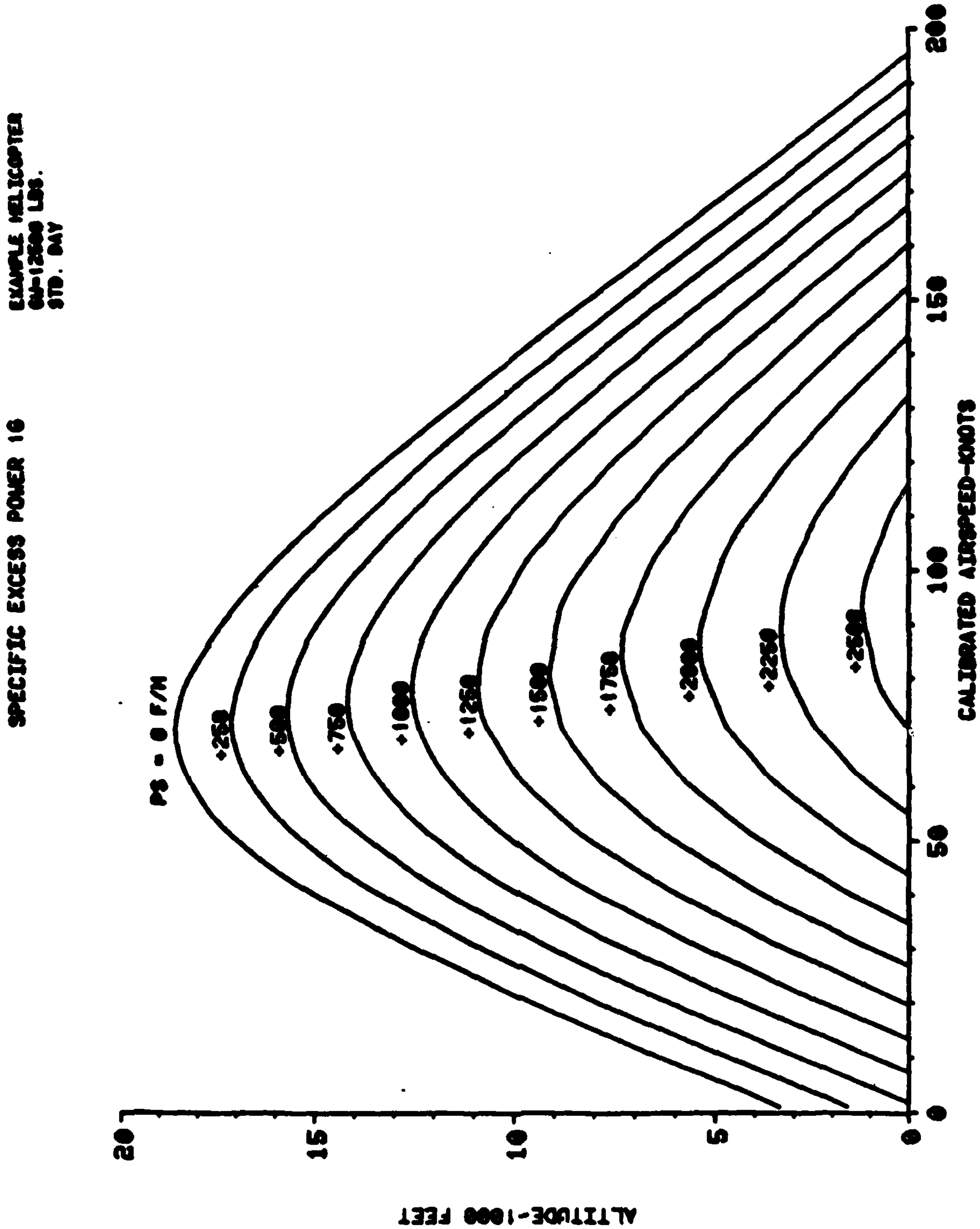

FIGURE A4. Sample P_s Tactical Manual Plot

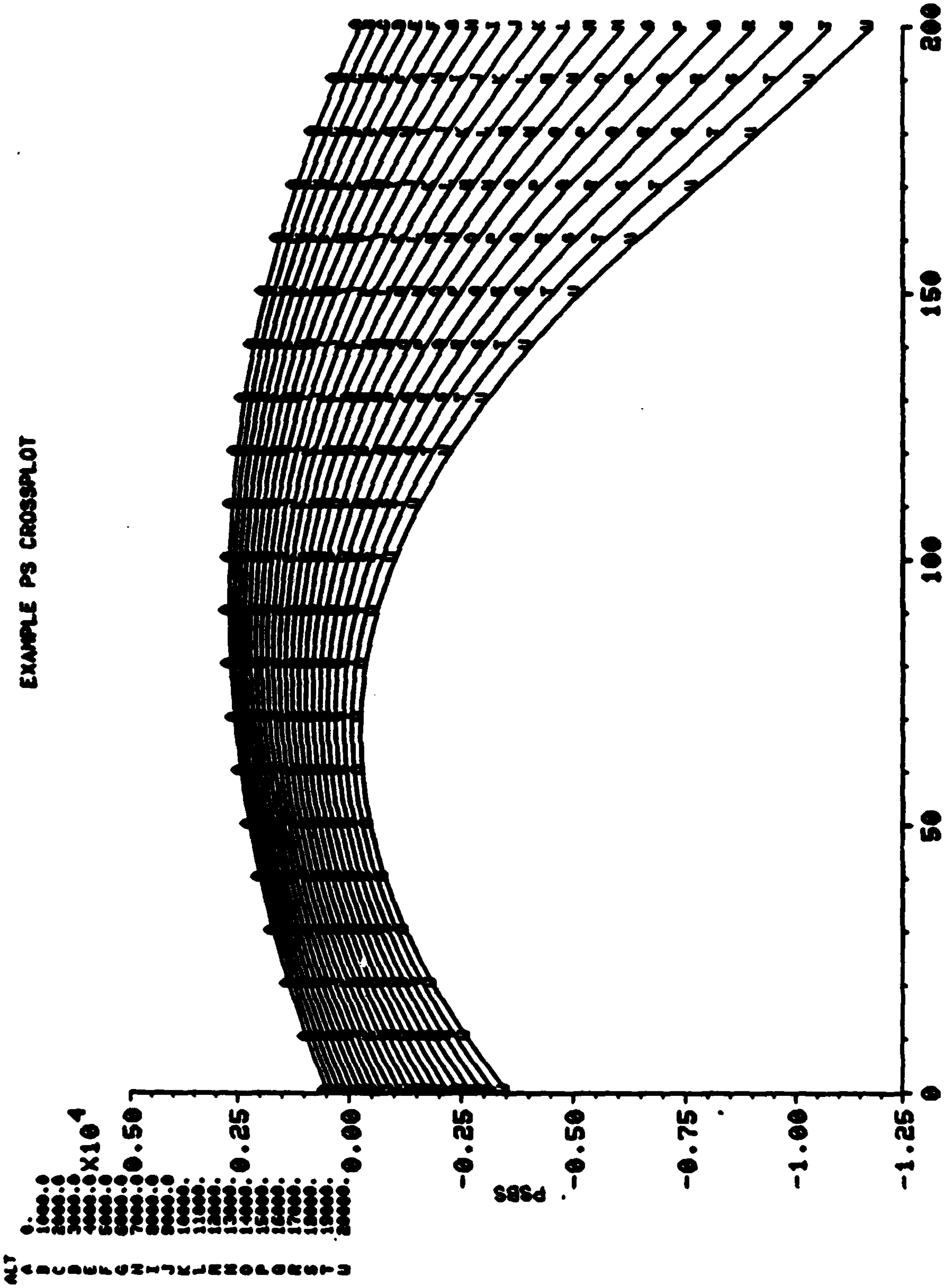

FIGURE A5. Sample TAPE6 P_s Crossplot

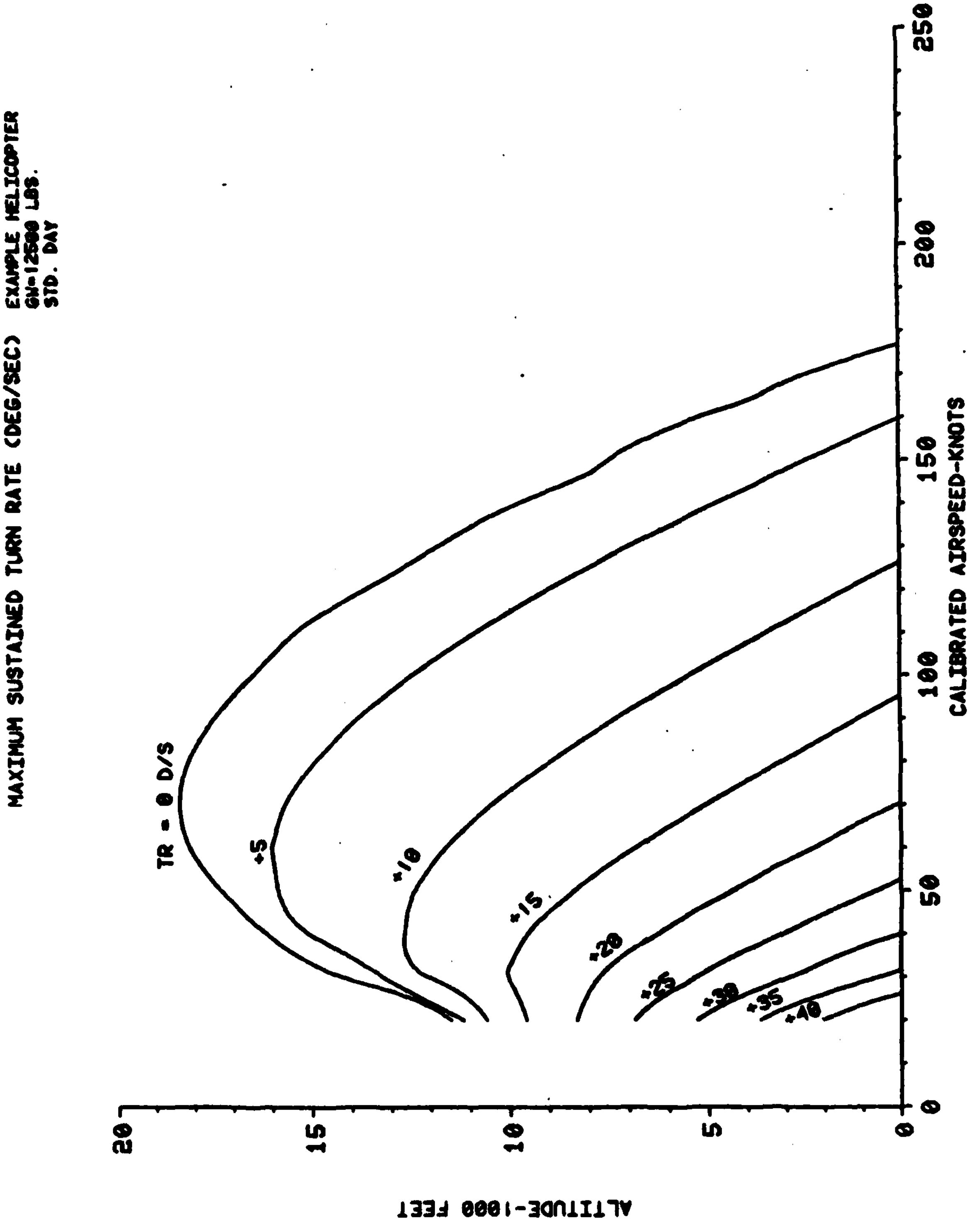

FIGURE A6. Sample Sustained $\dot{\psi}$ Tactical Manual Plot

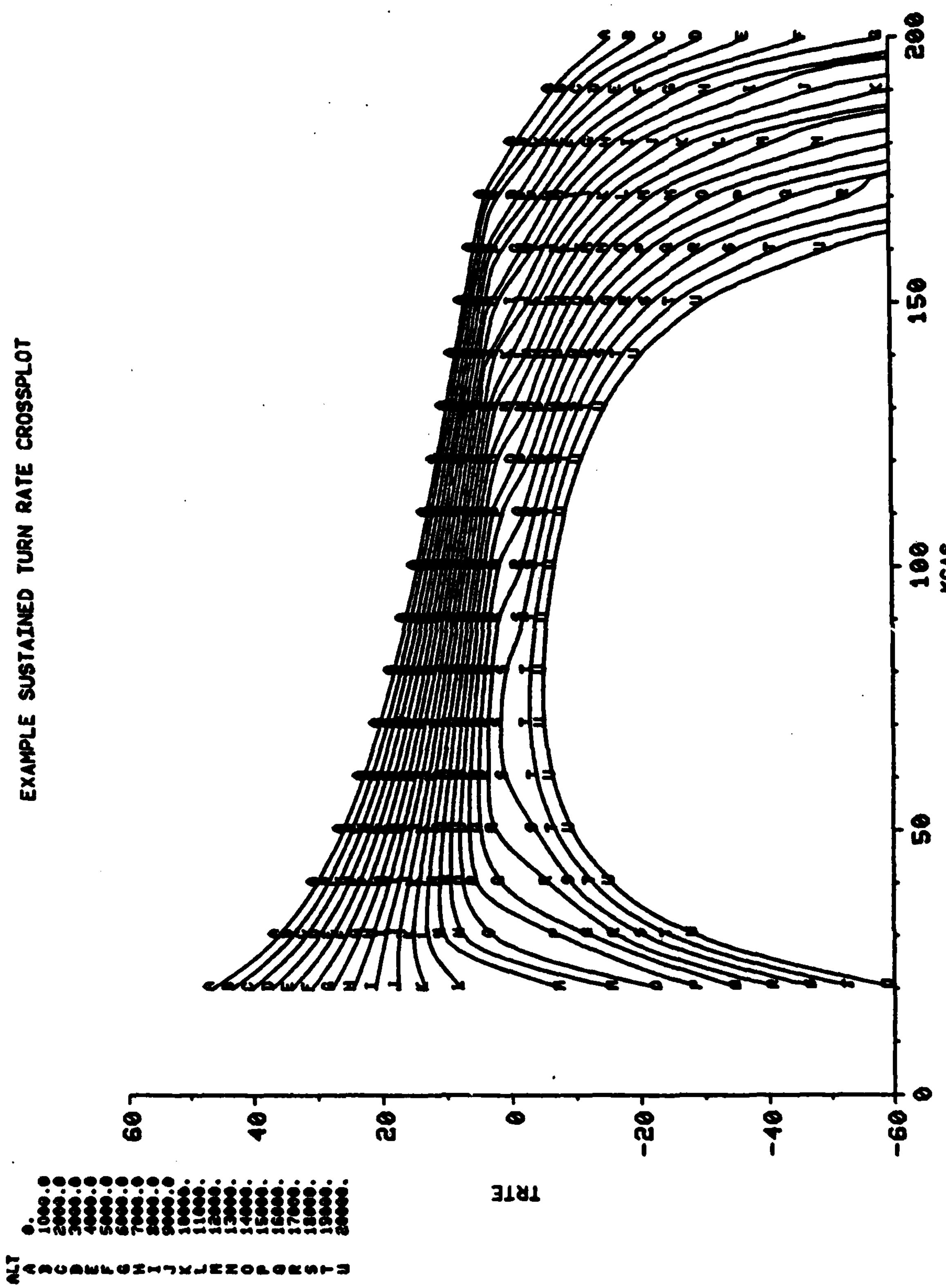

FIGURE A7. Sample TAPE6 Sustained $\dot{\psi}$ Crossplot

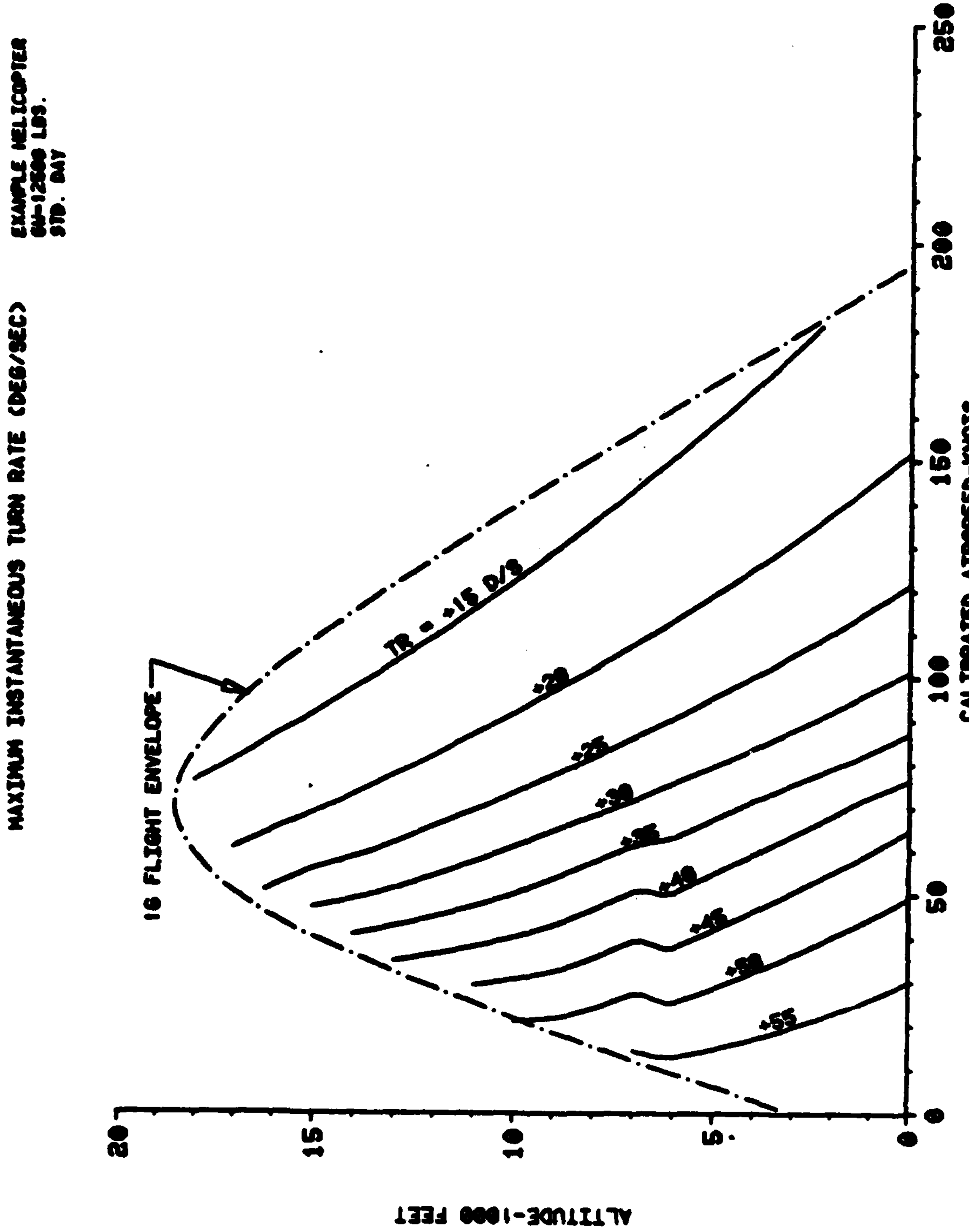

FIGURE A8. Sample Instantaneous $\dot{\psi}$ Tactical Manual Plot

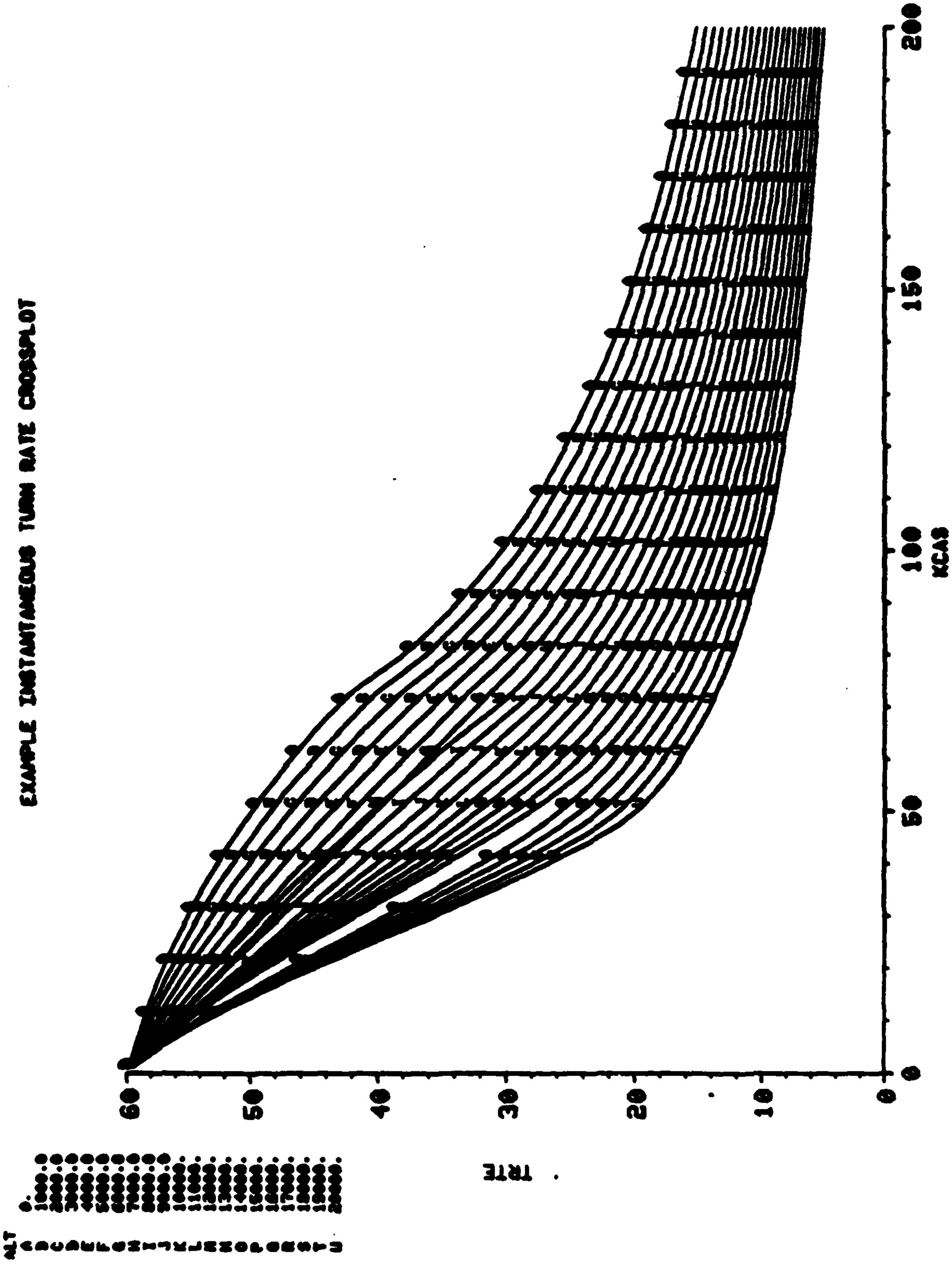

FIGURE A9. Sample TAPE6 Instantaneous ψ̇ Crossplot

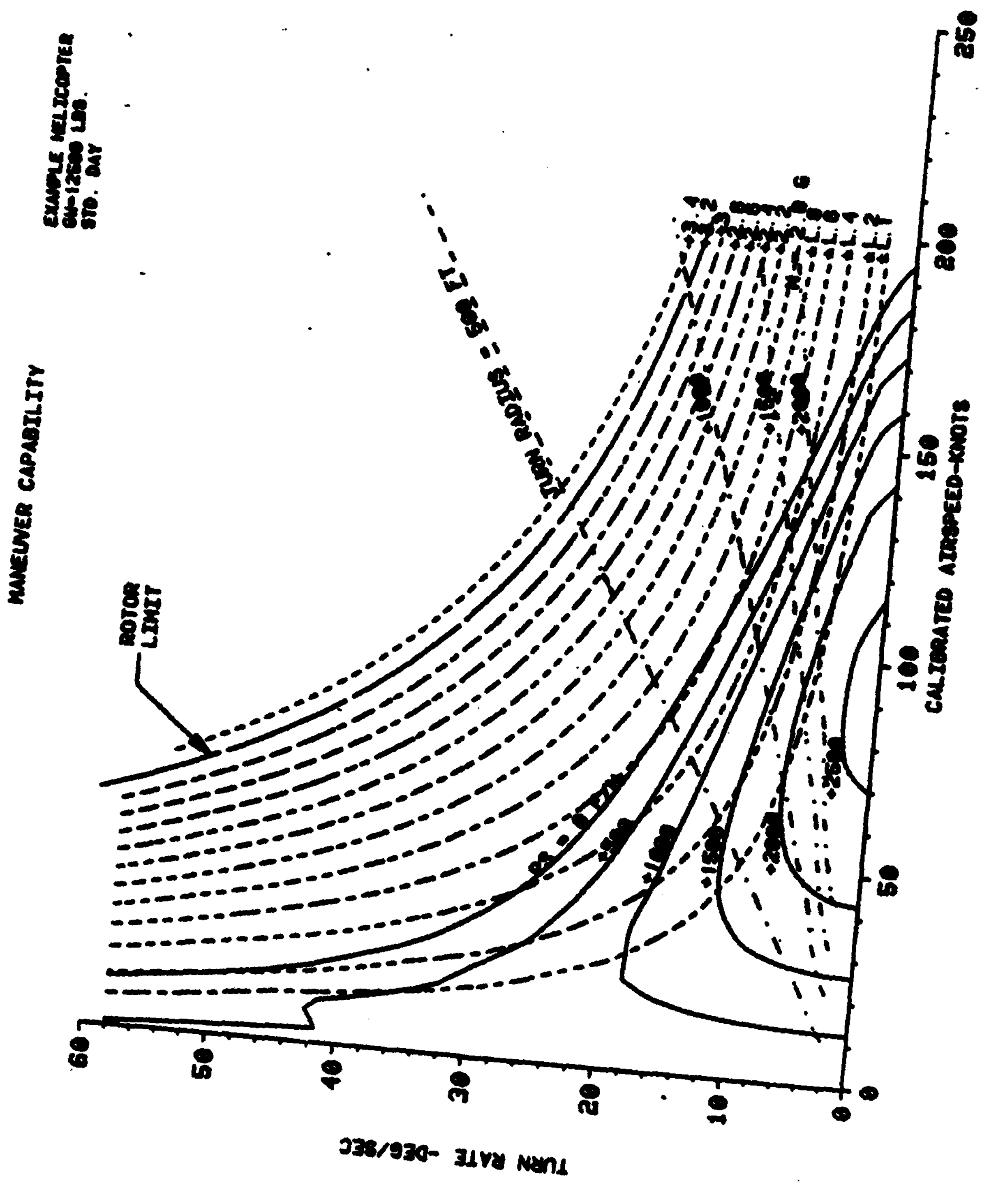

FIGURE A10. Sample Maneuver Tactical Manual Plot

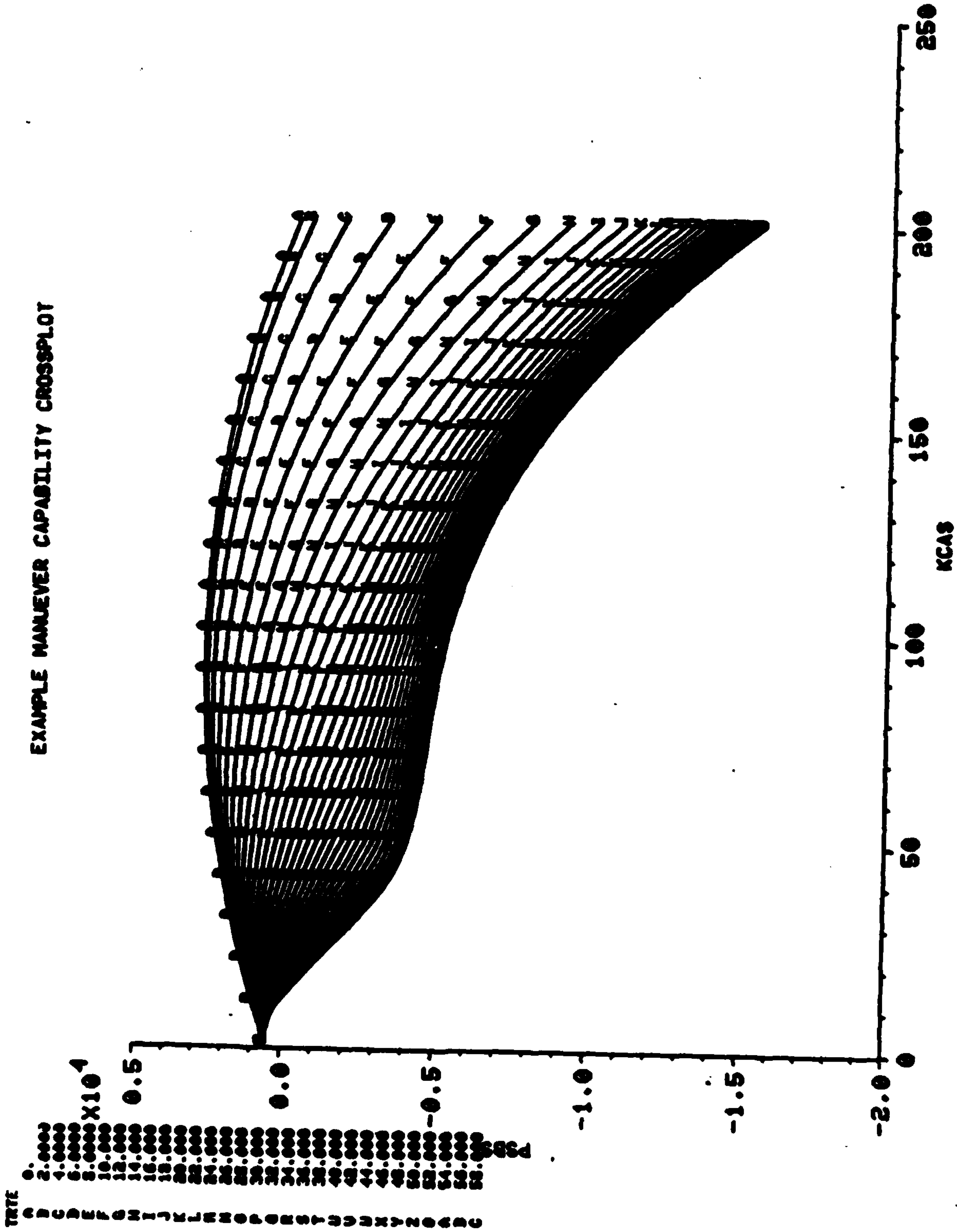

FIGURE A11. Sample TAPE6 Maneuver Crossplot

APPENDIX B

PROGRAM LISTINGS

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```
CPSHELO
      PROGRAM PSHELO(INPUT,OUTPUT,TAPE5=INPUT,TAPE10,TAPE6,
     1TAPE8)
      COMMON/PRINT/NPRINT
      COMMON/IOUNITS/IP,IR,ID
      DIMENSION CTA(100),PSS(100,100),XTAS(100),XALT(100),
     *V(100),ITITLE(7),XCAS(100)
      NAMELIST/D/NCAS,NALT,DELCAS,DELTALT,IATYPE,CPIRP,VTIP,UNV,
     1CAS1,ALT1,CTVAL,KATMOS,GFAC,TOGW,ADISK,TORFAC,PLIMIT,
     2ETAM,ETAP,DELFE,NPRINT,TMAN,TCHAR,MUCTSW,XMSN,IPRINT,
     3DELHP,CTMAX,TRV0,VB,NTRNRT,DELTRT,ALT0,
     4PSIMAX
      DATA IP,IR,ID/10,5,10/
      DATA TORFAC,PLIMIT,TMAN,TCHAR,MUCTSW/0.,1.E6,0.,1.,0/
      DATA PSIMAX/60./
      DATA ETAM,ETAP,DELFE/1.,1.,0./
      DATA XMSN,IPRINT,DELHP/100.,0,0/
      DATA TMAN,TCHAR,NPRINT/0.,1.,0./
      READ(5,D)
      IF(EOF(5))10,9
   10 STOP
    9 CONTINUE
      READ(5,1)ITITLE
    1 FORMAT(7A10)
      CALL TREAD(1,XD,YD,ZD,FXYZ)
   11 WRITE(8,2)ITITLE
      PRINT(10,D)
      IF(IPRINT.NE.0)PRINT(10,*)"PS,G,MU,V,ALT,CT,CPI,RHO,CPR"
    2 FORMAT(*APS01G1*,7A10)
      WRITE(8,*)NCAS,NALT,CAS1,DELCAS,ALT1,DELTALT,IATYPE
      NV=INT(UNV)
      L=1
      CTA(L)=CTVAL
      CT=CTA(L)
```

```
50 DO 100 IALT=1,NALT
   XALT(IALT)=FLOAT(IALT-1)*DELTALT
   CALL ATMOS(KATMOS,XALT(IALT),TEMPR,PRESSR,RHO,SIGMA,VSND)
   CT0=TOGW/(RHO*ADISK*VTIP**2)
   CT=GFAC*TOGW/(RHO*ADISK*VTIP**2)
   XOATC=(TEMPR-491.69)*5./9.
C
C
C  ********************************
C
C
   IF(TORFAC.EQ.0.)GOTO 58
   PLIMIT=XMSN*TORFAC
   CALL TLOOK(10,XOATC,XALT(IALT),0.,TORK)
   PWR=TORK*TORFAC
   GOTO 59
58 CALL TLOOK(10,XALT(IALT),XOATC,0.,PWR)
59 CONTINUE
   IF(PWR.GT.PLIMIT)PWR=PLIMIT
   CPIRP=(PWR*550.)/(RHO*ADISK*VTIP**3)
C
C  ***********************************
C
60 DO 100 ICAS=1,NCAS
   XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS
   XTAS(ICAS)=XCAS(ICAS)/(SIGMA)**.5
   IF(TMAN.EQ.0.)GOTO 39
   PWR1=PWR*TMAN*EXP(TCHAR*XTAS(ICAS))+DELHP*XTAS(ICAS)
   IF(PWR1.GT.PLIMIT)PWR1=PLIMIT
   CPIRP=(PWR1*550.)/(RHO*ADISK*VTIP**3)
39 V(ICAS)=XTAS(ICAS)*1.689/VTIP
   IF(MUCTSW.EQ.0)CALL TLOOK(9,CT,V(ICAS),0.,CPREQ)
   IF(MUCTSW.NE.0)CALL TLOOK(9,V(ICAS),CT,0.,CPREQ)
   DELCPR=.5*DELFE*V(ICAS)**3/(ADISK*ETAM*ETAP)
```

```
      CPREQ=CPREQ+DELCPR
      PSS(IALT,ICAS)=(CPIRP-CPREQ)*60.*.875*.90*VTIP/CT0
C
      IF(IPRINT.NE.0)PRINT(10,31)PSS(IALT,ICAS),GFAC,V(ICAS),
     *XCAS(ICAS),XALT(IALT),CT,CPIRP,RHO,CPREQ
   31 FORMAT(5X,5(1H*),9G13.5)
  100 CONTINUE
C
C  ***************************************
C  THIS SECTION LOADS THE ARRAY IN THE
C  REQUIRED FORMAT OF TREAD
C
      DATA IT/100/
      WRITE(6,17)IT,ITITLE
   17 FORMAT(I5,T11,7A10)
      WRITE(6,18)GFAC
   18 FORMAT(4HGFAC,3H  1,T11,F10.0)
      WRITE(6,19)NALT,(XALT(IALT),IALT=1,NALT)
   19 FORMAT(4HALT ,T6,I2,(T11,7F10.0))
      WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)
   21 FORMAT(4HKTAS,T6,I2,(T11,7F10.0))
C
  150 DO 200 IALT=1,NALT
      WRITE(6,23)NCAS,(PSS(IALT,ICAS),ICAS=1,NCAS)
   23 FORMAT(4HPSBS,T6,I2,(T11,7F10.1))
C
C
  200 CONTINUE
      WRITE(6,25)
   25 FORMAT(*EOT*/80(1H ))
C
C
C************************************************************************
C                 ACM8 INPUT ON TAPE8
```

```
C*******************************************************************************
      IC=NALT/9+1.001
      JE=0
      DO 810 K=1,IC
      JO=JE+1
      JE=MIN0(JO+8,NALT)
      DO 810 I=1,NCAS
      IF(I.EQ.1)WRITE(8,801)(XALT(J),J=JO,JE)
  801 FORMAT(*VEL/ALT  *,9F13.0)
      WRITE(8,800)(XCAS(I),(PSS(J,I),J=JO,JE))
  800 FORMAT(10G13.5)
  810 CONTINUE
C    ******************************
C
      READ(5,D)
      IF(EOF(5))10,11

      END
```

```
CSUSTURN
      PROGRAM SUSTURN(INPUT,OUTPUT,TAPE5=INPUT,TAPE10,TAPE6,
     1TAPE8)
      COMMON/PRINT/NPRINT
      COMMON/IOUNITS/IP,IR,ID
      DIMENSION CTA(100),PSIDOT(100,100),XTAS(100),XALT(100),
     *U(100),ITITLE(7),XCAS(100)
      NAMELIST/D/NCAS,NALT,DELCAS,DELTALT,IATYPE,CPIRP,UTIP,UNU,
     1CAS1,ALT1,CTVAL,KATMOS,GFAC,TOGW,ADISK,TORFAC,PLIMIT,
     2ETAM,ETAP,DELFE,NPRINT,TMAN,TCHAR,MUCTSW,XMSN,
     3IPRINT,DELHP,CTMAX,TRV0,VB,NTRNRT,DELTRT,ALT0,
     4PSIMAX
      DATA IP,IR,ID/10,5,10/
      DATA TORFAC,PLIMIT,TMAN,TCHAR,MUCTSW/0.,1.E6,0.,1.,0/
      DATA ETAM,ETAP,DELFE/1.,1.,0./
      DATA XMSN,IPRINT,G,DELHP/100.,0,32.1741,0/
      DATA PSIMAX/60./
      READ(5,D)
      IF(EOF(5))10,9
   10 STOP
    9 CONTINUE
      READ(5,1)ITITLE
    1 FORMAT(7A10)
      CALL TREAD(1,XD,YD,ZD,FXYZ)
   11 WRITE(8,2)ITITLE
      PRINT(10,D)
      IF(IPRINT.NE.0)PRINT(10,*)'PSIDOT,G,MU,V,ALT,CT,CPI,RHO'
    2 FORMAT(*ACZGA12*,7A10)
      WRITE(8,*)NCAS,NALT,CAS1,DELCAS,ALT1,DELTALT,IATYPE
      NU=INT(UNU)
      L=1
      CTA(L)=CTVAL
      CT=CTA(L)
   50 DO 100 IALT=1,NALT
```

```
      XALT(IALT)=FLOAT(IALT-1)*DELTALT
      CALL ATMOS(KATMOS,XALT(IALT),TEMPR,PRESSR,RHO,SIGMA,VSND)
      XOATC=(TEMPR-491.69)*5./9.
C
C
C    ********************************
C
C
      IF(TORFAC.EQ.0.)GOTO 58
      PLIMIT=XMSN*TORFAC
      CALL TLOOK(10,XOATC,XALT(IALT),0.,TORK)
      PWR=TORK*TORFAC
      GOTO 59
   58 CALL TLOOK(10,XALT(IALT),XOATC,0.,PWR)
   59 CONTINUE
      IF(PWR.GT.PLIMIT)PWR=PLIMIT
      CPIRP=(PWR*550.)/(RHO*ADISK*VTIP**3)
C
C    ***********************************
C
   60 DO 100 ICAS=1,NCAS
      XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS+CAS1
      IF(XCAS(ICAS).EQ.0.)XCAS(ICAS)=1.E-6
      XTAS(ICAS)=XCAS(ICAS)/(SIGMA)**.5
      IF(TMAN.EQ.0.)GOTO 39
      PWR1=PWR*TMAN*EXP(TCHAR*XTAS(ICAS))+DELHP*XTAS(ICAS)
      IF(PWR1.GT.PLIMIT)PWR1=PLIMIT
      CPIRP=(PWR1*550.)/(RHO*ADISK*VTIP**3)
   39 V(ICAS)=XTAS(ICAS)*1.689/VTIP
      DELCPR=.5*DELFE*V(ICAS)**3/(ADISK*ETAM*ETAP)
      CPREQ=CPIRP-DELCPR
      CALL TLOOK(11,CPREQ,V(ICAS),0.,CT)
      IF(CT.LT.0.)PSIDOT(IALT,ICAS)=-1000.
      IF(CT.LT.0.)GO TO 41
```

```
      GFAC=CT*RHO*ADISK*VTIP**2/TOGW
      KSIGN=0
      IF(GFAC.LT.0.)KSIGN=1
      IF(GFAC.LT.0.)GFAC=-GFAC
      IF(GFAC.GE.1.)GO TO 40
      XXXX=1.+(1./((1.-GFAC**2)**.5-1.))
      PSIDOT(IALT,ICAS)=(G*XXXX/(XTAS(ICAS)*1.689))*57.29578
      IF(KSIGN.EQ.1)PSIDOT(IALT,ICAS)=-PSIDOT(IALT,ICAS)
      GO TO 41
   40 PSIDOT(IALT,ICAS)=(G*(GFAC**2-1)**.5/(XTAS(ICAS)*1.689))*57.29578
      IF(PSIDOT(IALT,ICAS).GE.PSIMAX)PSIDOT(IALT,ICAS)=PSIMAX
      IF(KSIGN.EQ.1)PSIDOT(IALT,ICAS)=-PSIDOT(IALT,ICAS)
   41 CONTINUE
C
      IF(IPRINT.NE.0)PRINT(10,31)PSIDOT(IALT,ICAS),GFAC,V(ICAS),
     *XCAS(ICAS),XALT(IALT),CT,CPIRP,RHO
   31 FORMAT(5X,5(1H*),8G13.5)
  100 CONTINUE
C
C    *************************************
C    THIS SECTION LOADS THE ARRAY IN THE
C    REQUIRED FORMAT OF TREAD
C
      DATA IT/100/
      WRITE(6,17)IT,ITITLE
   17 FORMAT(I5,T11,7A10)
      WRITE(6,18)GFAC
   18 FORMAT(4HGFAC,3H  1,T11,F10.0)
      WRITE(6,19)NALT,(XALT(IALT),IALT=1,NALT)
   19 FORMAT(4HALT ,T6,I2,(T11,7F10.0))
      WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)
   21 FORMAT(4HKTAS,T6,I2,(T11,7F10.0))
C
  150 DO 200 IALT=1,NALT
```

```
      WRITE(6,23)NCAS,(PSIDOT(IALT,ICAS),ICAS=1,NCAS)
   23 FORMAT(4HTRTE,T6,I2,(T11,7F10.1))
C
C
  200 CONTINUE
      WRITE(6,25)
   25 FORMAT(*EOT*/80(1H ))
C
C
C***********************************************************************
C                 ACM8 INPUT ON TAPE8
C***********************************************************************
      IC=NALT/9+1.001
      JE=0
      DO 810 K=1,IC
      JO=JE+1
      JE=MIN0(JO+8,NALT)
      DO 810 I=1,NCAS
      IF(I.EQ.1)WRITE(8,801)(XALT(J),J=JO,JE)
  801 FORMAT(*VEL/ALT  *,9F13.0)
      WRITE(8,800)(XCAS(I),(PSIDOT(J,I),J=JO,JE))
  800 FORMAT(10G13.5)
  810 CONTINUE
C   ******************************
C
      READ(5,D)
      IF(EOF(5))10,11

      END
```

```
CINSTURN
      PROGRAM INSTURN(INPUT,OUTPUT,TAPE5=INPUT,TAPE10,TAPE6,
     1TAPE8)
      COMMON/PRINT/NPRINT
      COMMON/IOUNITS/IP,IR,ID
      DIMENSION CTA(100),PSIDOT(100,100),XTAS(100),XALT(100),
     *ITITLE(7),ARRAY(20),XCAS(100)
      NAMELIST/D/NCAS,NALT,DELCAS,DELTALT,IATYPE,CPIRP,VTIP,UNV,
     1CAS1,ALT1,CTVAL,KATMOS,GFAC,TOGW,ADISK,TORFAC,PLIMIT,
     2ETAM,ETAP,DELFE,NPRINT,TMAN,TCHAR,MUCTSW,XMSN,
     3IPRINT,CTMAX,TRV0,VB,DELHP,NTRNRT,DELTRT,ALT0,
     4PSIMAX
      DATA IP,IR,ID/10,5,10/
      DATA TORFAC,PLIMIT,TMAN,TCHAR,MUCTSW/0.,1.E6,0.,1.,0/
      DATA ETAM,ETAP,DELFE/1.,1.,0./
      DATA XMSN,IPRINT,G/100.,0,32.1741/
      DATA PSIMAX/60./
      READ(5,D)
      IF(EOF(5))10,9
   10 STOP
    9 CONTINUE
      READ(5,1)ITITLE
    1 FORMAT(7A10)
      CALL TREAD(1,XD,YD,ZD,FXYZ)
   11 WRITE(8,2)ITITLE
      PRINT(10,D)
      IF(IPRINT.NE.0)PRINT(10,*)"PSIDOT,G,CTMAX,V,ALT,CT,CPI,RHO"
    2 FORMAT(*ACZGA12*,7A10)
      WRITE(8,*)NCAS,NALT,CAS1,DELCAS,ALT1,DELTALT,IATYPE
      NV=INT(UNV)
      L=1
      CTA(L)=CTVAL
      CT=CTA(L)
      ARRAY(1)=4
```

```
      ARRAY(2)=-1.
      ARRAY(3)=0.
      ARRAY(6)=ARRAY(7)=TRV0
   50 DO 100 IALT=1,NALT
      XALT(IALT)=FLOAT(IALT-1)*DELTALT
      KATMOS=3.
      CALL ATMOS(KATMOS,XALT(IALT),TEMPR,PRESSR,RHO,SIGMA,VSND)
      GFAC=CTMAX*RHO*ADISK*VTIP**2/TOGW
   60 DO 101 ICAS=1,NCAS
      XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS+CAS1
      IF(XCAS(ICAS).EQ.0.)XCAS(ICAS)=1.E-6
      XTAS(ICAS)=XCAS(ICAS)/(SIGMA)**.5
      KSIGN=0
      IF(GFAC.LT.0.)KSIGN=1
      IF(GFAC.LT.0.)GFAC=-GFAC
      IF(GFAC.GE.1.)GO TO 40
      XXXX=1.+(1./((1.-GFAC**2)**.5-1.))
      PSIDOT(IALT,ICAS)=(G*XXXX/(XTAS(ICAS)*1.689))*57.29578
      IF(KSIGN.EQ.1)PSIDOT(IALT,ICAS)=-PSIDOT(IALT,ICAS)
      GO TO 41
   40 PSIDOT(IALT,ICAS)=(G*(GFAC**2-1)**.5/(XTAS(ICAS)*1.689))*57.29578
      IF(KSIGN.EQ.1)PSIDOT(IALT,ICAS)=-PSIDOT(IALT,ICAS)
   41 CONTINUE
C
      IF(IPRINT.NE.0)PRINT(10,31)PSIDOT(IALT,ICAS),GFAC,CTMAX,
     *XCAS(ICAS),XALT(IALT),CT,CPIRP,RHO
   31 FORMAT(5X,5(1H*),8G13.5)
  101 CONTINUE
      NCAS1=NCAS-1
      DO 102 I=1,NCAS1
      L=NCAS-I
      IF(XTAS(L).LE.VB)103,102
  103 ARRAY(10)=0.
      ARRAY(11)=1.
```

```
      ARRAY(4)=XTAS(L)
      ARRAY(5)=XTAS(L+1)
      ARRAY(8)=PSIDOT(IALT,L)
      ARRAY(9)=PSIDOT(IALT,L+1)
      DO 105 K=1,L
  105 PSIDOT(IALT,K)=SPLNQ1(1,ARRAY,XTAS(K))
      IF(XTAS(NCAS).LE.VB)PSIDOT(IALT,NCAS)=
     CSPLNQ1(1,ARRAY,XTAS(NCAS))
      GOTO 100
  102 CONTINUE
  100 CONTINUE
C
C    ****************************************
C    THIS SECTION LOADS THE ARRAY IN THE
C    REQUIRED FORMAT OF TREAD
C
      DATA IT/100/
      WRITE(6,17)IT,ITITLE
   17 FORMAT(I5,T11,7A10)
      WRITE(6,18)GFAC
   18 FORMAT(4HGFAC,3H  1,T11,F10.0)
      WRITE(6,19)NALT,(XALT(IALT),IALT=1,NALT)
   19 FORMAT(4HALT ,T6,I2,(T11,7F10.0))
      WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)
   21 FORMAT(4HKTAS,T6,I2,(T11,7F10.0))
C
  150 DO 200 IALT=1,NALT
      WRITE(6,23)NCAS,(PSIDOT(IALT,ICAS),ICAS=1,NCAS)
   23 FORMAT(4HTRTE,T6,I2,(T11,7F10.1))
C
C
  200 CONTINUE
      WRITE(6,25)
   25 FORMAT(*EOT*/80(1H ))
```

```
C
C
C*********************************************************************
C              ACM8 INPUT ON TAPE8
C*********************************************************************
      IC=NALT/9+1.001
      JE=0
      DO 810 K=1,IC
      JO=JE+1
      JE=MIN0(JO+8,NALT)
      DO 810 I=1,NCAS
      IF(I.EQ.1)WRITE(8,801)(XALT(J),J=JO,JE)
  801 FORMAT(*VEL/ALT  *,9F13.0)
      WRITE(8,800)(XCAS(I),(PSIDOT(J,I),J=JO,JE))
  800 FORMAT(10G13.5)
  810 CONTINUE
C   *****************************
C
      READ(5,D)
      IF(EOF(5))10,11

      END
```

```
CMANEUV
      PROGRAM MANEUV(INPUT,OUTPUT,TAPE5=INPUT,TAPE10,TAPE6,
     1TAPE8,TAPE9)
      COMMON/PRINT/NPRINT
      COMMON/IOUNITS/IP,IR,ID
      DIMENSION PSS(75,75),XTAS(100),PSIDOT(100),TR(75),
     *V(100),ITITLE(7),XCAS(100),RAD(75,75),GFACT(75,75)
      NAMELIST/D/NCAS,NALT,DELCAS,DELTALT,IATYPE,CPIRP,VTIP,UNV,
     1CAS1,ALT1,CTVAL,KATMOS,GFAC,TOGW,ADISK,TORFAC,PLIMIT,
     2ETAM,ETAP,DELFE,NPRINT,TMAN,TCHAR,MUCTSW,XMSN,IPRINT,
     3DELHP,CTMAX,TRV0,VB,ALT0,NTRNRT,DELTRT,TRT1
      DATA IP,IR,ID/10,5,10/
      DATA TORFAC,PLIMIT,TMAN,TCHAR,MUCTSW/0.,1.E6,0.,1.,0/
      DATA ETAM,ETAP,DELFE/1.,1.,0./
      DATA XMSN,IPRINT,DELHP/100.,0,0/
      DATA G,NTRNRT,DELTRT,ALT0/32.1741,24.,1.,0./
      DATA TRT1/.1/
      READ(5,D)
      IF(EOF(5))10,9
   10 STOP
    9 CONTINUE
      READ(5,1)ITITLE
    1 FORMAT(7A10)
      CALL TREAD(1,XD,YD,ZD,FXYZ)
   11 WRITE(8,2)ITITLE
      PRINT(10,D)
      IF(IPRINT.NE.0)PRINT(10,*)"PS,G,MU,V,ALT,CT,CPI,RHO,CPR"
    2 FORMAT(*APS01G1*,7A10)
      WRITE(8,*)NCAS,NTRNRT,CAS1,DELCAS,TRT1,DELTRT,IATYPE
      CALL ATMOS(KATMOS,ALT0,TEMPR,PRESSR,RHO,SIGMA,VSND)
      XOATC=(TEMPR-491.69)*5./9.
      CT1=GFAC*TOGW/(RHO*ADISK*VTIP**2)
C
C
```

```
C     ********************************
C
C
      IF(TORFAC.EQ.0.)GOTO 58
      PLIMIT=XMSN*TORFAC
      CALL TLOOK(10,XOATC,ALT0,0.,TORK)
      PWR=TORK*TORFAC
      GOTO 59
   58 CALL TLOOK(10,ALT0,XOATC,0.,PWR)
   59 CONTINUE
      IF(PWR.GT.PLIMIT)PWR=PLIMIT
      CPIRP=(PWR*550.)/(RHO*ADISK*VTIP**3)
C
C     **********************************
C
      GMAX=CTMAX*RHO*ADISK*VTIP**2/TOGW
      GTOP=GMAX+.5
   50 DO 100 ITRNRT=1,NTRNRT
      PSIDOT(ITRNRT)=FLOAT(ITRNRT-1)*DELTRT+TRT1
C
C
   60 DO 100 ICAS=1,NCAS
      XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS+CAS1
      XTAS(ICAS)=XCAS(ICAS)/SIGMA**.5
      V(ICAS)=XTAS(ICAS)*1.689/VTIP
      GFACT(ITRNRT,ICAS)=
     *      ((PSIDOT(ITRNRT)*XTAS(ICAS)*.029479/G)**2+1.)**.5
      IF(TMAN.EQ.0.)GOTO 39
      PWR1=PWR*TMAN*EXP(TCHAR*XTAS(ICAS))+DELHP*XTAS(ICAS)
      IF(PWR1.GT.PLIMIT)PWR1=PLIMIT
      CPIRP=(PWR1*550.)/(RHO*ADISK*VTIP**3)
   39 CONTINUE
      CT=CT1*GFACT(ITRNRT,ICAS)
      IF(MUCTSW.EQ.0)CALL TLOOK(9,CT,V(ICAS),0.,CPREQ)
```

```
      IF(MUCTSW.NE.0)CALL TLOOK(9,V(ICAS),CT,0.,CPREQ)
      DELCPR=.5*DELFE*V(ICAS)**3/(ADISK*ETAM*ETAP)
      CPREQ=CPREQ+DELCPR
      PSS(ITRNRT,ICAS)=(CPIRP-CPREQ)*.875*.90*VTIP*60./CT
C*****************************************************************
      RAD(ITRNRT,ICAS)=1.689*57.29578*XTAS(ICAS)/PSIDOT(ITRNRT)
C*************************************************************
      IF(GFACT(ITRNRT,ICAS).GT.GTOP)GFACT(ITRNRT,ICAS)=-2.E10
C
      IF(IPRINT.NE.0)PRINT(10,31)PSS(ITRNRT,ICAS),GFACT(ITRNRT,ICAS)
     *,V(ICAS),XTAS(ICAS),PSIDOT(ITRNRT),CT,CPIRP,RHO,CPREQ
   31 FORMAT(5X,5(1H*),9G13.5)
  100 CONTINUE
C
C    ***************************************
C    THIS SECTION LOADS THE ARRAY IN THE
C    REQUIRED FORMAT OF TREAD
C
      DATA IT/100/
      WRITE(6,17)IT,ITITLE
   17 FORMAT(I5,T11,7A10)
      WRITE(6,18)GFAC
   18 FORMAT(4HGFAC,3H  1,T11,F10.0)
      WRITE(6,19)NTRNRT,(PSIDOT(ITRNRT),ITRNRT=1,NTRNRT)
   19 FORMAT(4HALT ,T6,I2,(T11,7F10.0))
      WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)
   21 FORMAT(4HKTAS,T6,I2,(T11,7F10.0))
C
  150 DO 200 ITRNRT=1,NTRNRT
      WRITE(6,23)NCAS,(PSS(ITRNRT,ICAS),ICAS=1,NCAS)
   23 FORMAT(4HPSBS,T6,I2,(T11,7F10.1))
C
C
  200 CONTINUE
```

```
      WRITE(6,25)
   25 FORMAT(*EOT*/80(1H ))
C
C
C***********************************************************************
C                   ACM6 INPUT ON TAPE8
C***********************************************************************
      IC=NTRNRT/9+1.001
      JE=0
      DO 810 K=1,IC
      JO=JE+1
      JE=MIN0(JO+8,NTRNRT)
      DO 810 I=1,NCAS
      IF(I.EQ.1)WRITE(8,801)(PSIDOT(J),J=JO,JE)
  801 FORMAT(*VEL/ALT  *,9F13.5)
      WRITE(8,800)(XCAS(I),(PSS(J,I),J=JO,JE))
  800 FORMAT(10G13.5)
  810 CONTINUE
C    ******************************
      WRITE(8,2)ITITLE
      WRITE(8,*)NCAS,NTRNRT,CAS1,DELCAS,TRT1,DELTRT,IATYPE
C***********************************************************************
      IC=NTRNRT/9+1.001
      JE=0
      DO 860 K=1,IC
      JO=JE+1
      JE=MIN0(JO+8,NTRNRT)
      DO 860 I=1,NCAS
      IF(I.EQ.1)WRITE(8,851)(PSIDOT(J),J=JO,JE)
  851 FORMAT(*VEL/ALT  *,9F13.5)
      WRITE(8,850)(XCAS(I),(GFACT(J,I),J=JO,JE))
  850 FORMAT(10G13.5)
  860 CONTINUE
C    ******************************
```

```
      WRITE(8,2)ITITLE
       NTRNRT=NTRNRT-1
      WRITE(8,*)NCAS,NTRNRT,CAS1,DELCAS,PSIDOT(2),DELTRT,IATYPE
C***********************************************************************
      IC=NTRNRT/9+1.001
      JE=1
      DO 910 K=1,IC
      JO=JE+1
      JE=MIN0(JO+8,NTRNRT)
      DO 910 I=1,NCAS
      IF(I.EQ.1)WRITE(8,901)(PSIDOT(J),J=JO,JE)
  901 FORMAT(*VEL/ALT  *,9F13.5)
      WRITE(8,900)(XCAS(I),(RAD(J,I),J=JO,JE))
  900 FORMAT(10G13.5)
  910 CONTINUE
C   *****************************
C*******************************************************************
      IQ=1
      IF(XCAS(1).EQ.0.)IQ=2
      NCAS1=NCAS+1-IQ
      DO 950 ICAS=IQ,NCAS
  950 TR(ICAS)=G*((GMAX**2-1.)**.5/(XTAS(ICAS)*1.689))
     **57.29578
      ITIT=4HMACH
      WRITE(9,951)ITIT,NCAS1,(XCAS(I),I=IQ,NCAS)
      ITIT=4HALT
      WRITE(9,951)ITIT,NCAS1,(TR(I),I=IQ,NCAS)
  951 FORMAT(A4,1X,I2,*612*,(T11,7F10.5))
      WRITE(9,952)XCAS(NCAS-5),TR(NCAS-5)
  952 FORMAT(*....000*,T11,*.15*,T21,F10.5,T31,F10.5,
     //*ROTOR   LIMIT*)
C*******************************************************************
C
      READ(5,D)
```

```
IF(EOF(5))10,11
END
```

APPENDIX C

PROGRAM LOGIC

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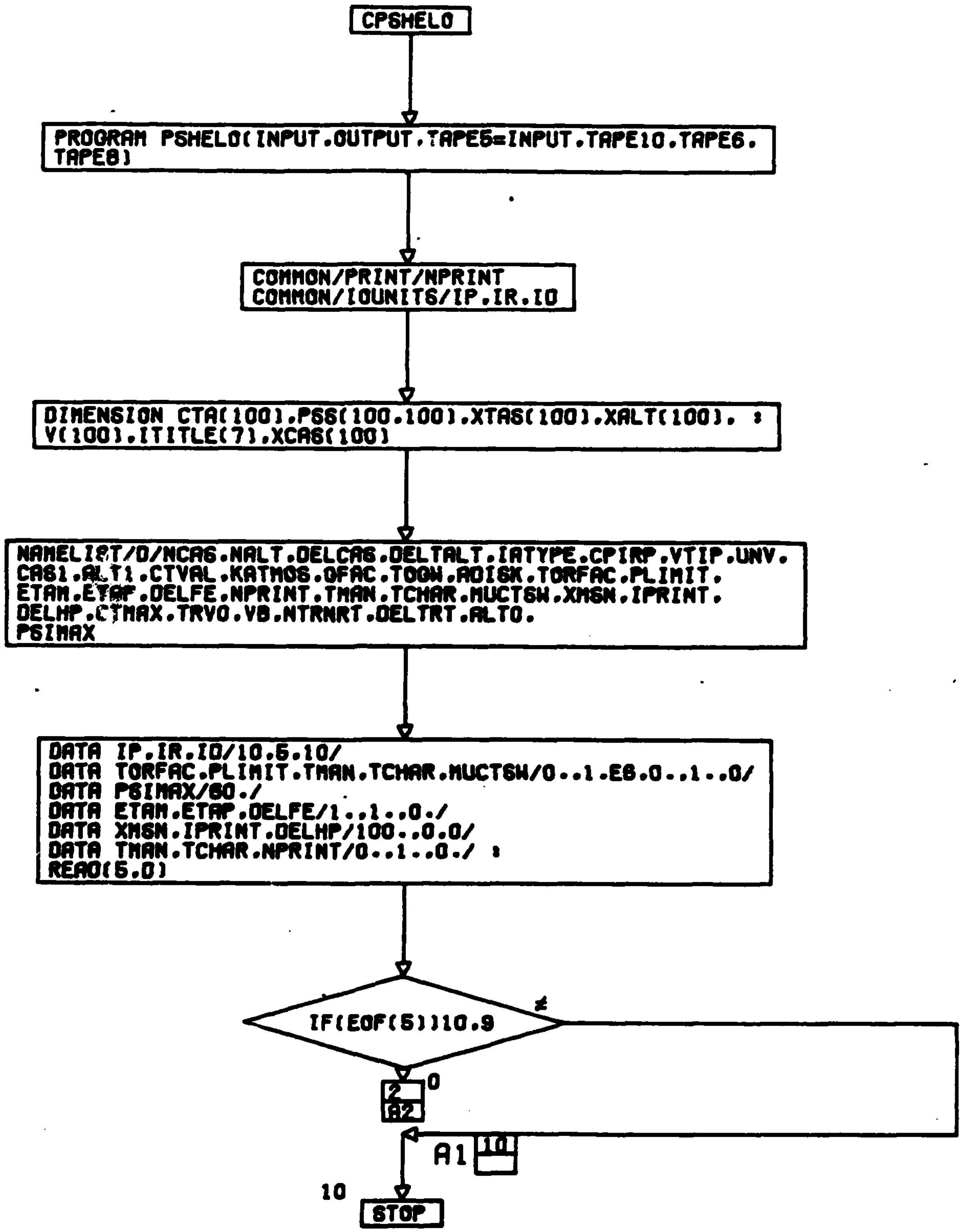
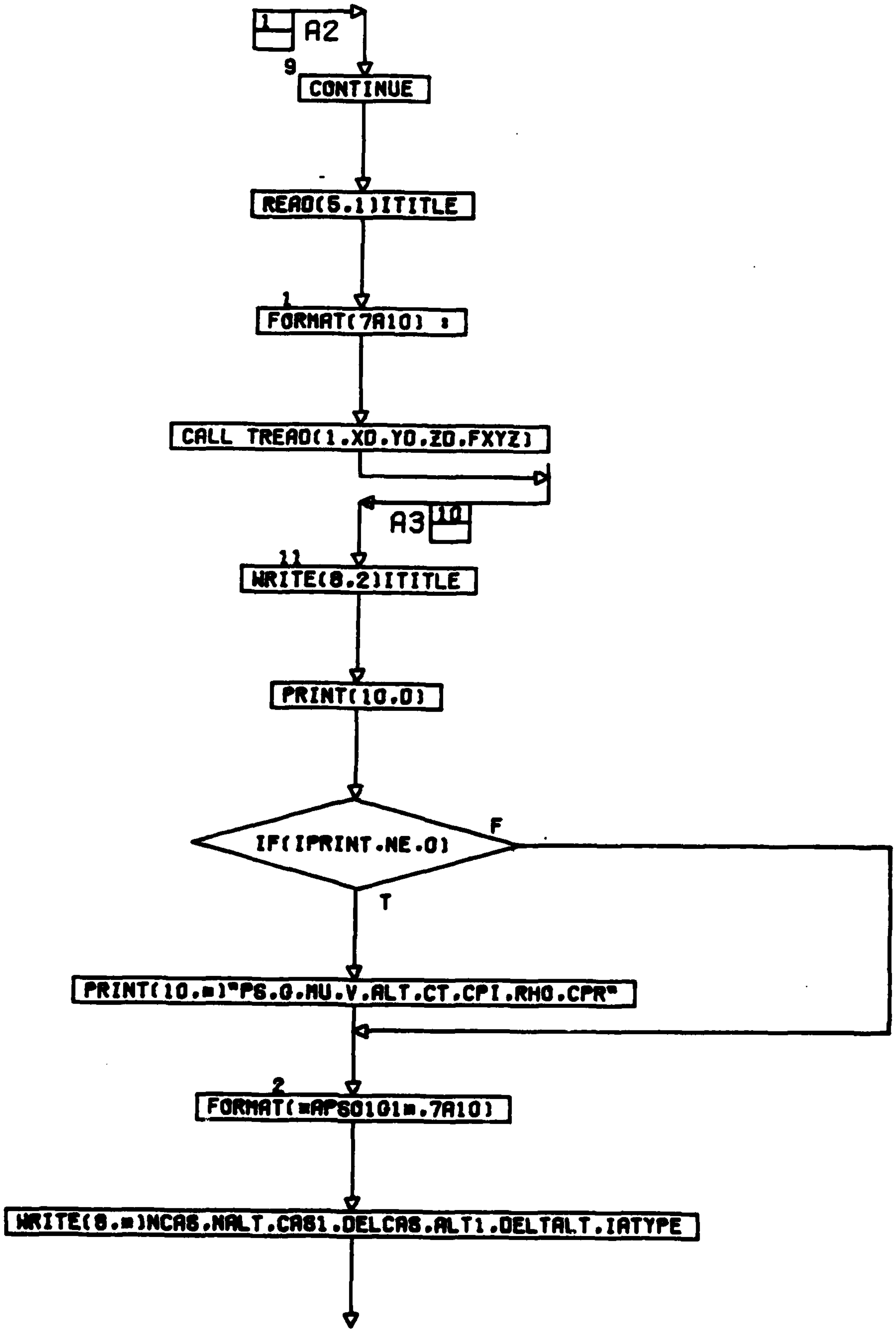
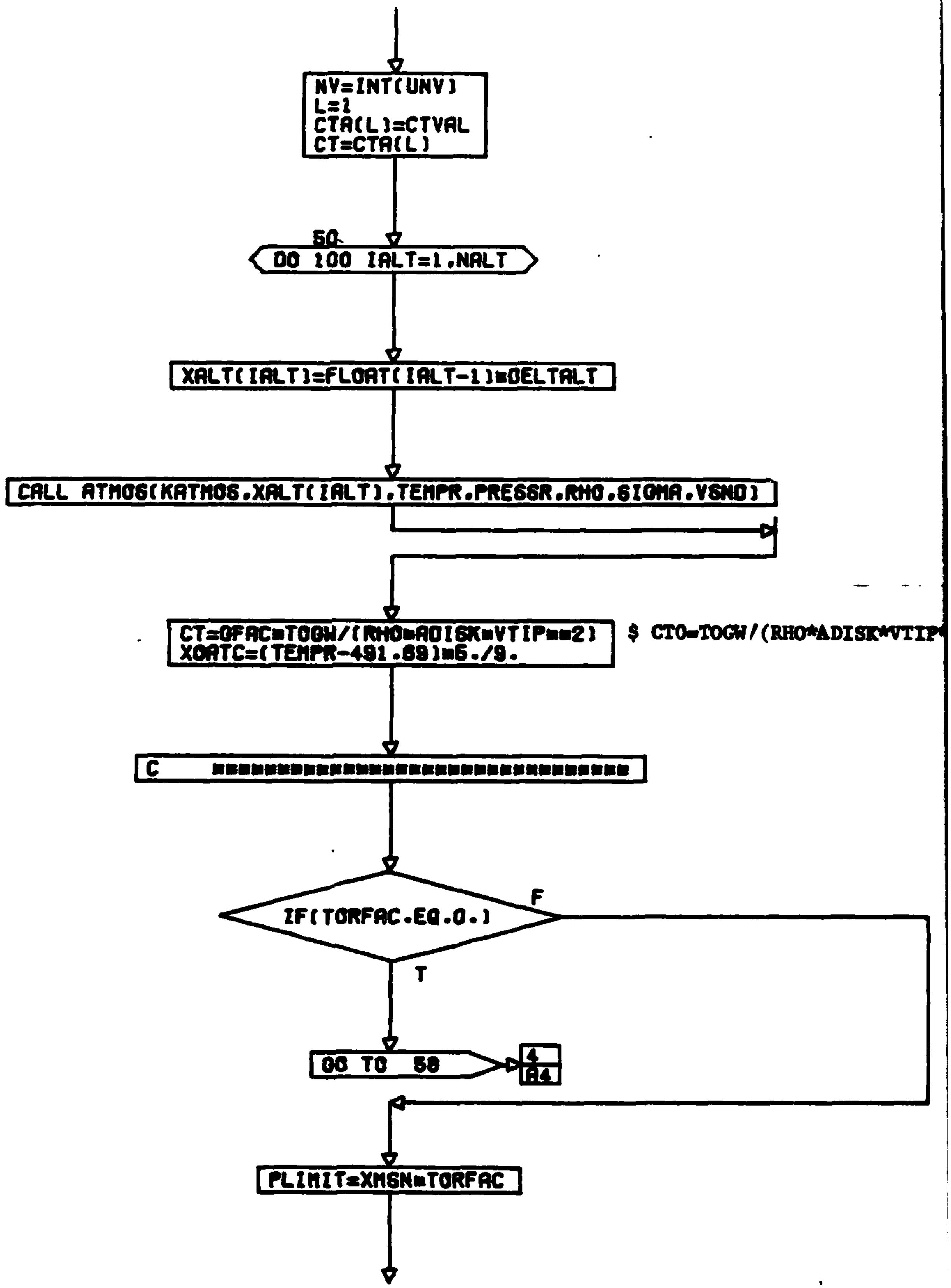

CPSHELO
PROGRAM PSHELO(INPUT,OUTPUT,TAPE5=INPUT,TAPE10,TAPE6,
TAPE8)
COMMON/PRINT/NPRINT
COMMON/IOUNITS/IP,IR,IO
DIMENSION CTA(100),PSS(100,100),XTAS(100),XALT(100), :
V(100),ITITLE(7),XCAS(100)
NAMELIST/D/NCAS,NALT,DELCAS,DELTALT,IATYPE,CPIRP,VTIP,UNV,
CAS1,ALT1,CTVAL,KATMOS,OFAC,TOGW,ADISK,TORFAC,PLIMIT,
ETAM,ETAP,DELFE,NPRINT,TMAN,TCHAR,MUCTSW,XMSN,IPRINT,
DELHP,CTMAX,TRVO,VB,NTRNRT,DELTRT,ALTO,
PSIMAX
DATA IP,IR,IO/10,5,10/
DATA TORFAC,PLIMIT,TMAN,TCHAR,MUCTSW/0.,1.E6,0.,1.,0/
DATA PSIMAX/60./
DATA ETAM,ETAP,DELFE/1.,1.,0./
DATA XMSN,IPRINT,DELHP/100.,0,0/
DATA TMAN,TCHAR,NPRINT/0.,1.,0./ :
READ(5,D)
IF(EOF(5))10,9
≠
0
2
A2
A1
10
10
STOP

CONT. ON PG 2

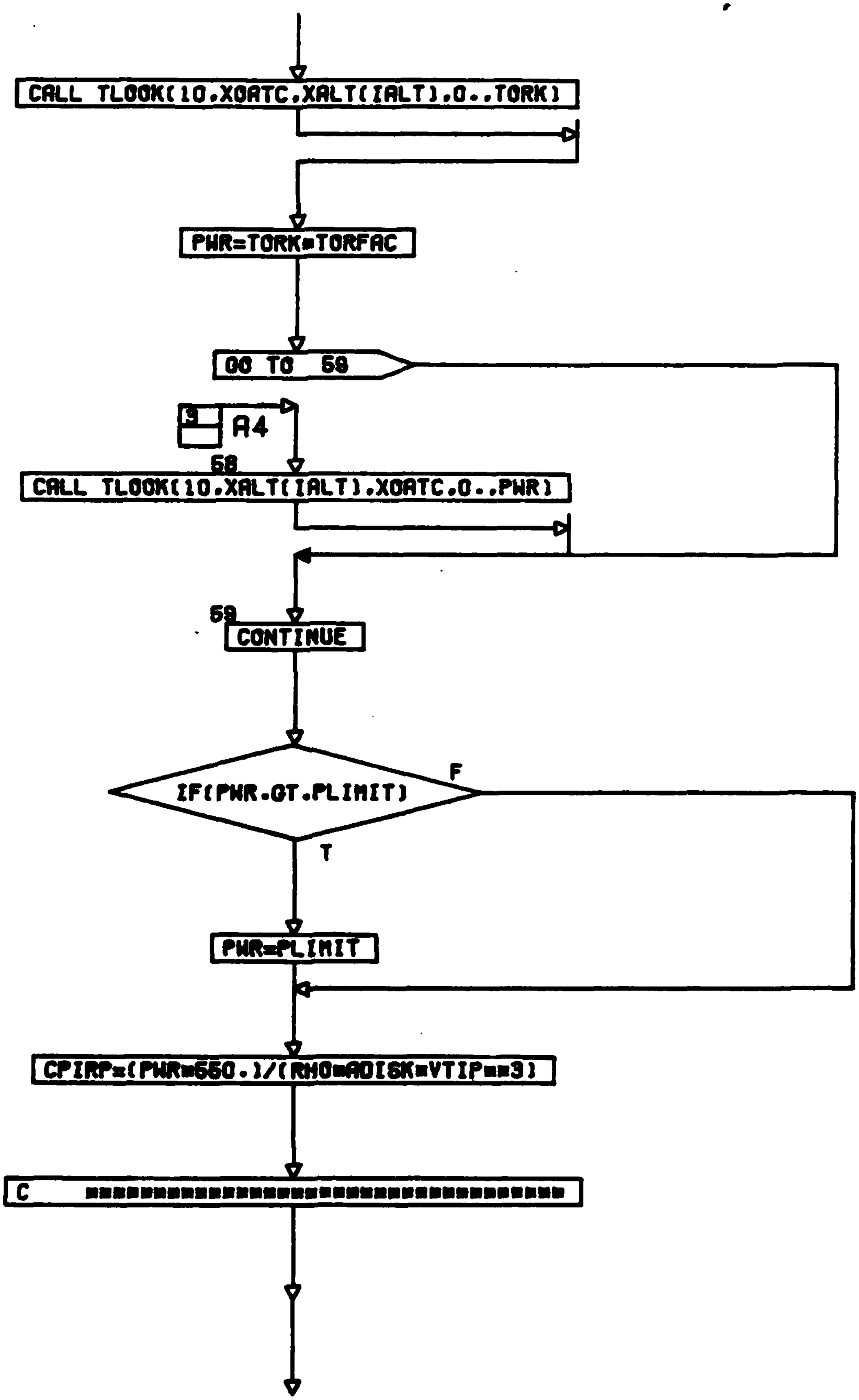


1
A2
9
CONTINUE
READ(5.1)ITITLE
1
FORMAT(7A10) :
CALL TREAD(1.XD.YD.ZD.FXYZ)
A3
10
11
WRITE(8.2)ITITLE
PRINT(10.D)
IF(IPRINT.NE.0)
F
T
PRINT(10.*)"PS.G.MU.V.ALT.CT.CPI.RHO.CPR"
2
FORMAT(*APS0101*.7A10)
WRITE(8.*)NCAS.NALT.CAS1.DELCAS.ALT1.DELTALT.IATYPE

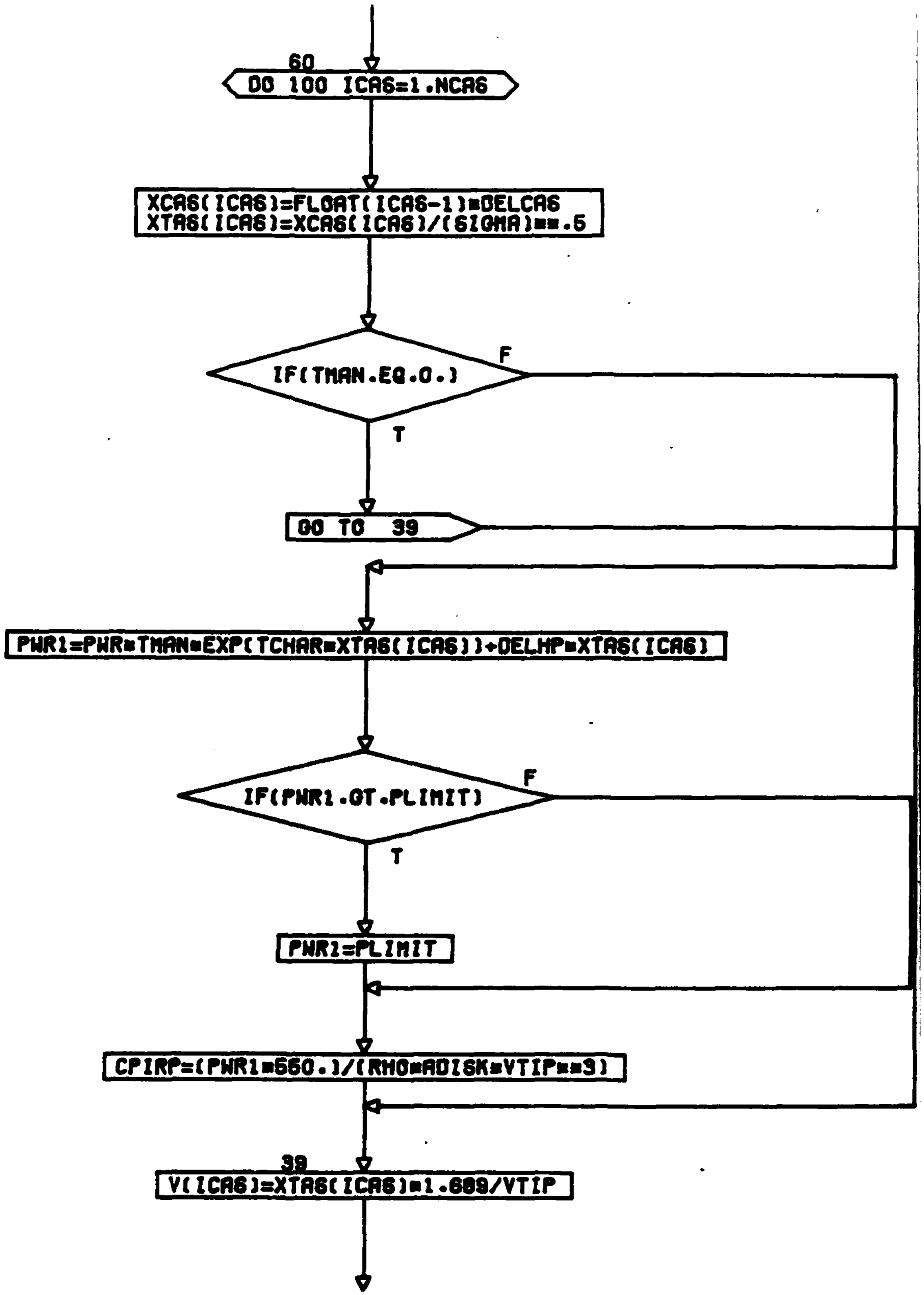
CONT. ON PG 3


NV=INT(UNV)
L=1
CTA(L)=CTVAL
CT=CTA(L)
50
DO 100 IALT=1,NALT
XALT(IALT)=FLOAT(IALT-1)*DELTALT
CALL ATMOS(KATMOS,XALT(IALT),TEMPR,PRESSR,RHO,SIGMA,VSND)
CT=GFAC*TOGW/(RHO*ADISK*VTIP**2)
XOATC=(TEMPR-491.69)*5./9.
$ CTO=TOGW/(RHO*ADISK*VTIP
C ********************************
IF(TORFAC.EQ.0.)
F
T
GO TO 58
4
A4
PLIMIT=XMSN*TORFAC

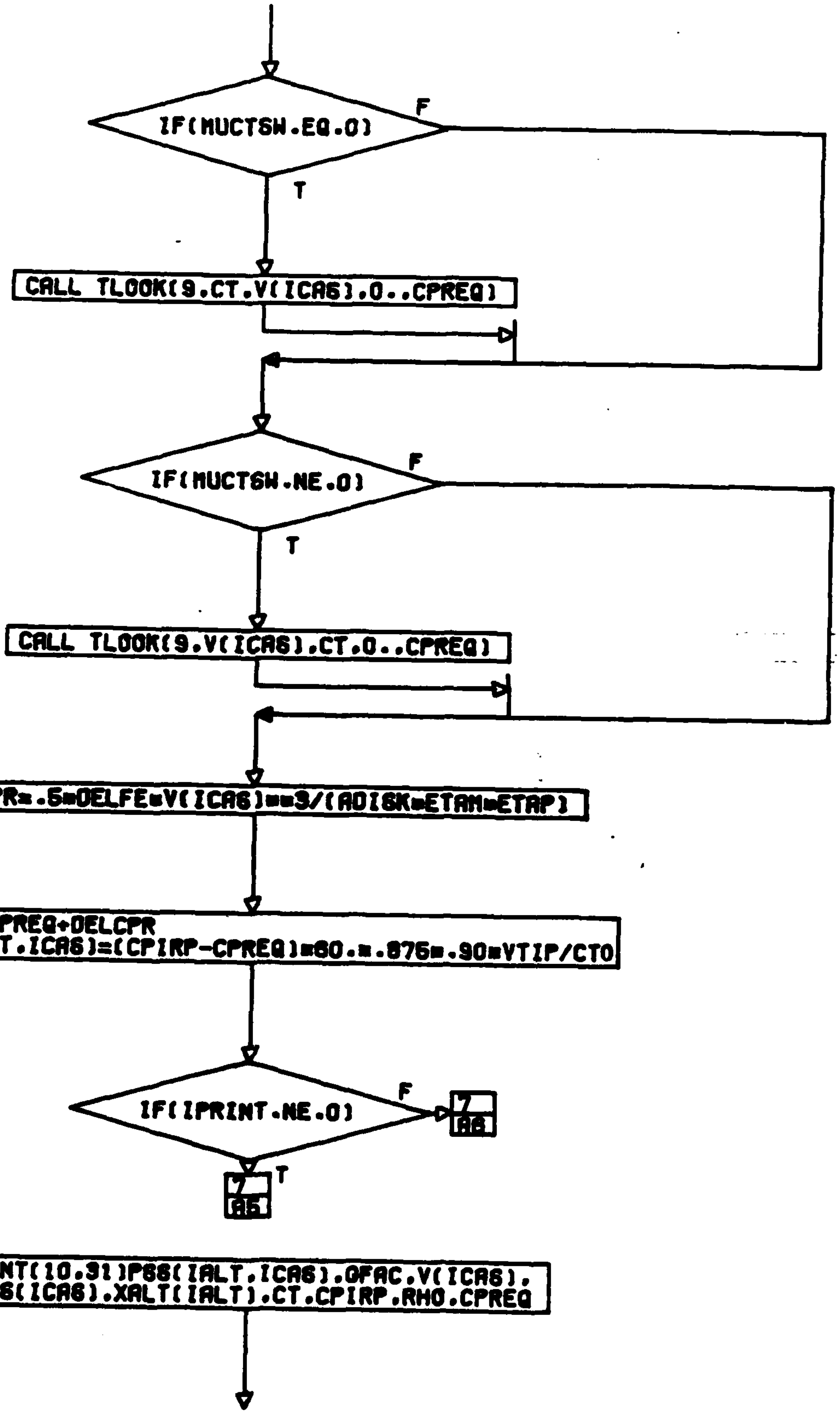
CONT. ON PG 4


CALL TLOOK(10,XOATC,XALT(IALT),0.,TORK)
PWR=TORK*TORFAC
GO TO 59
3
A4
58
CALL TLOOK(10,XALT(IALT),XOATC,0.,PWR)
59
CONTINUE
IF(PWR.GT.PLIMIT)
F
T
PWR=PLIMIT
CPIRP=(PWR*550.)/(RHO*ADISK*VTIP**3)
C ************************************

CONT. ON PG 5


60
DO 100 ICAS=1.NCAS
XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS
XTAS(ICAS)=XCAS(ICAS)/(SIGMA)**.5
IF(TMAN.EQ.0.)
F
T
GO TO 39
PWR1=PWR*TMAN*EXP(TCHAR*XTAS(ICAS))+DELHP*XTAS(ICAS)
IF(PWR1.GT.PLIMIT)
F
T
PWR1=PLIMIT
CPIRP=(PWR1*550.)/(RHO*ADISK*VTIP**3)
39
V(ICAS)=XTAS(ICAS)*1.689/VTIP

CONT. ON PG 6


IF(MUCTSW.EQ.0)
F
T
CALL TLOOK(9.CT.V(ICAS).0..CPREQ)
IF(MUCTSW.NE.0)
F
T
CALL TLOOK(9.V(ICAS).CT.0..CPREQ)
DELCPR=.5*DELFE*V(ICAS)**3/(ADISK*ETAM*ETAP)
CPREQ=CPREQ+DELCPR
PSS(IALT.ICAS)=(CPIRP-CPREQ)*60.*.876*.90*VTIP/CTO
IF(IPRINT.NE.0)
F
7
A6
T
7
A5
PRINT(10.31)PSS(IALT.ICAS).QFAC.V(ICAS).
XCAS(ICAS).XALT(IALT).CT.CPIRP.RHO.CPREQ

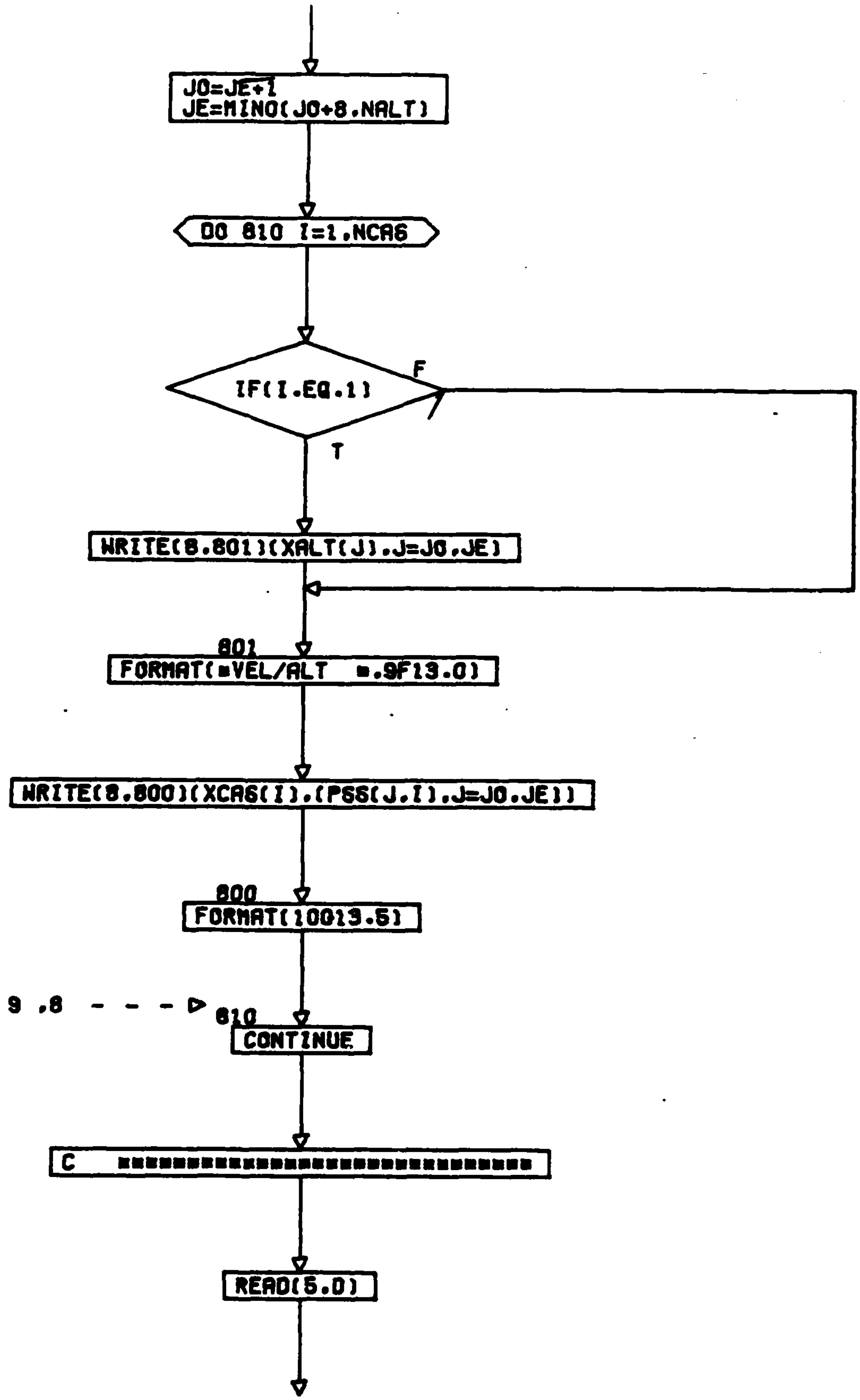
CONT. ON PG 7

```
6  A5

FORMAT(5X,5(1H*),9G13.5)

6  A6

5 ,3 - - - >
100
CONTINUE

C  **********************************
C  THIS SECTION LOADS THE ARRAY IN THE :
C  REQUIRED FORMAT OF TREAD

DATA IT/100/ :
WRITE(6,17)IT,ITITLE

17
FORMAT(I5,T11,7A10)

WRITE(6,18)GFAC

18
FORMAT(4HGFAC,3H   1,T11,F10.0)

WRITE(6,19)NALT,(XALT(IALT),IALT=1,NALT)

19
FORMAT(4HALT  ,T6,I2,(T11,7F10.0))

WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)
```

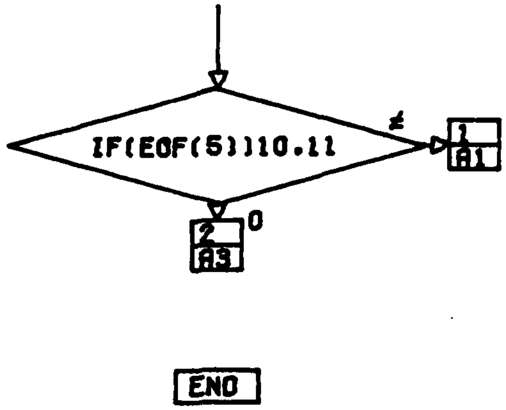
CONT. ON PG 8

```
21
FORMAT(4HKTAS.T6.I2.(T11,7F10.0))

150
DO 200 IALT=1.NALT

WRITE(6.23)NCAS.(PSS(IALT.ICAS).ICAS=1,NCAS)

23
FORMAT(4HPSBS.T6.I2.(T11,7F10.1))

8 - - - > 200
CONTINUE

WRITE(6.25)

25
FORMAT(*EOT*/80(1H ))

C**********************************************************************
C               ACM8 INPUT ON TAPE8
C**********************************************************************

IC=NALT/9+1.001
JE=0

DO 810 K=1.IC
```

CONT. ON PG 9


JO=JE+1
JE=MINO(JO+8,NALT)
DO 810 I=1,NCAS
IF(I.EQ.1)
F
T
WRITE(8,801)(XALT(J),J=JO,JE)
801
FORMAT(=VEL/ALT =,9F13.0)
WRITE(8,800)(XCAS(I),(PSS(J,I),J=JO,JE))
800
FORMAT(10G13.5)
9 ,8
810
CONTINUE
C ****************************
READ(5,D)

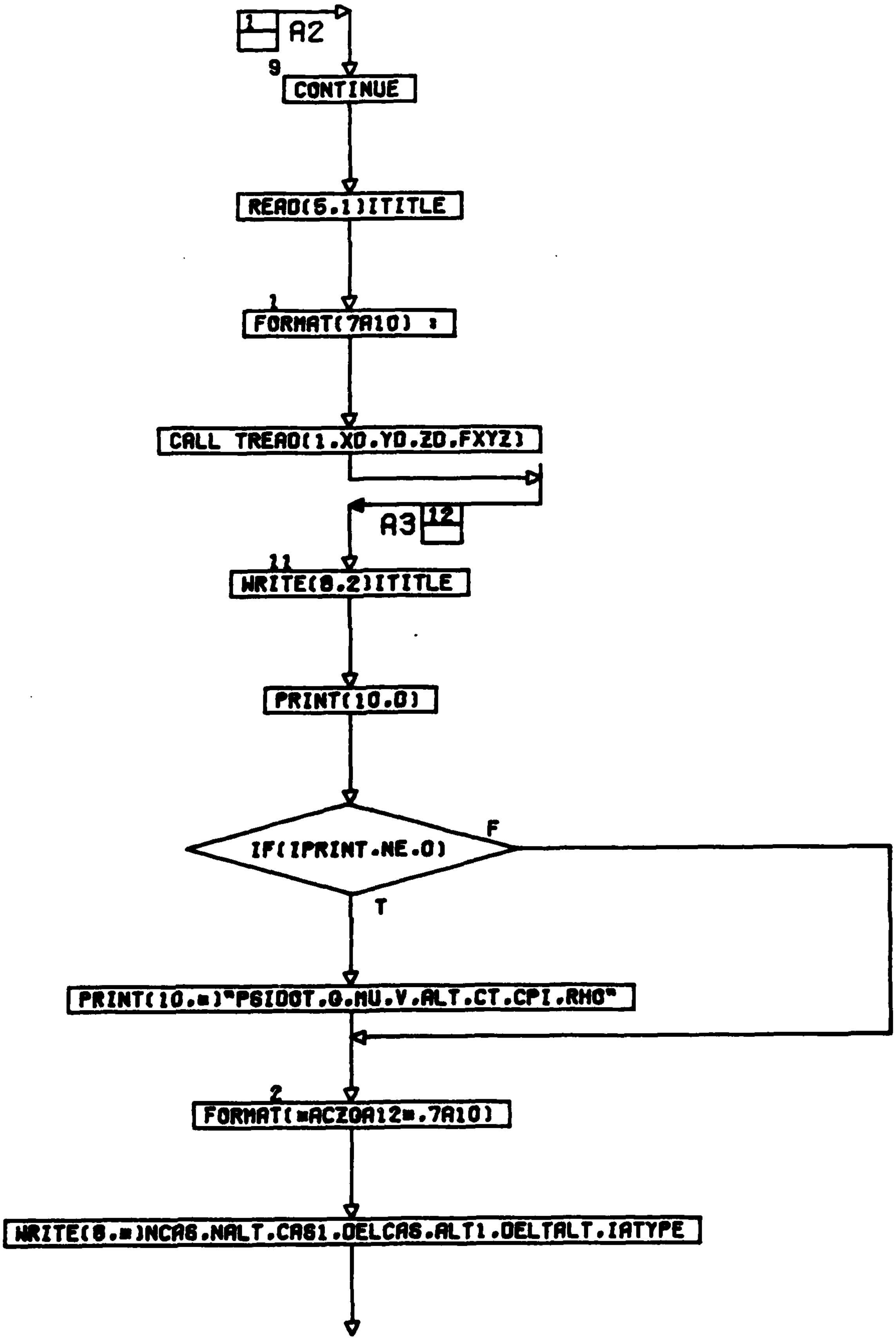
CONT. ON PG 10



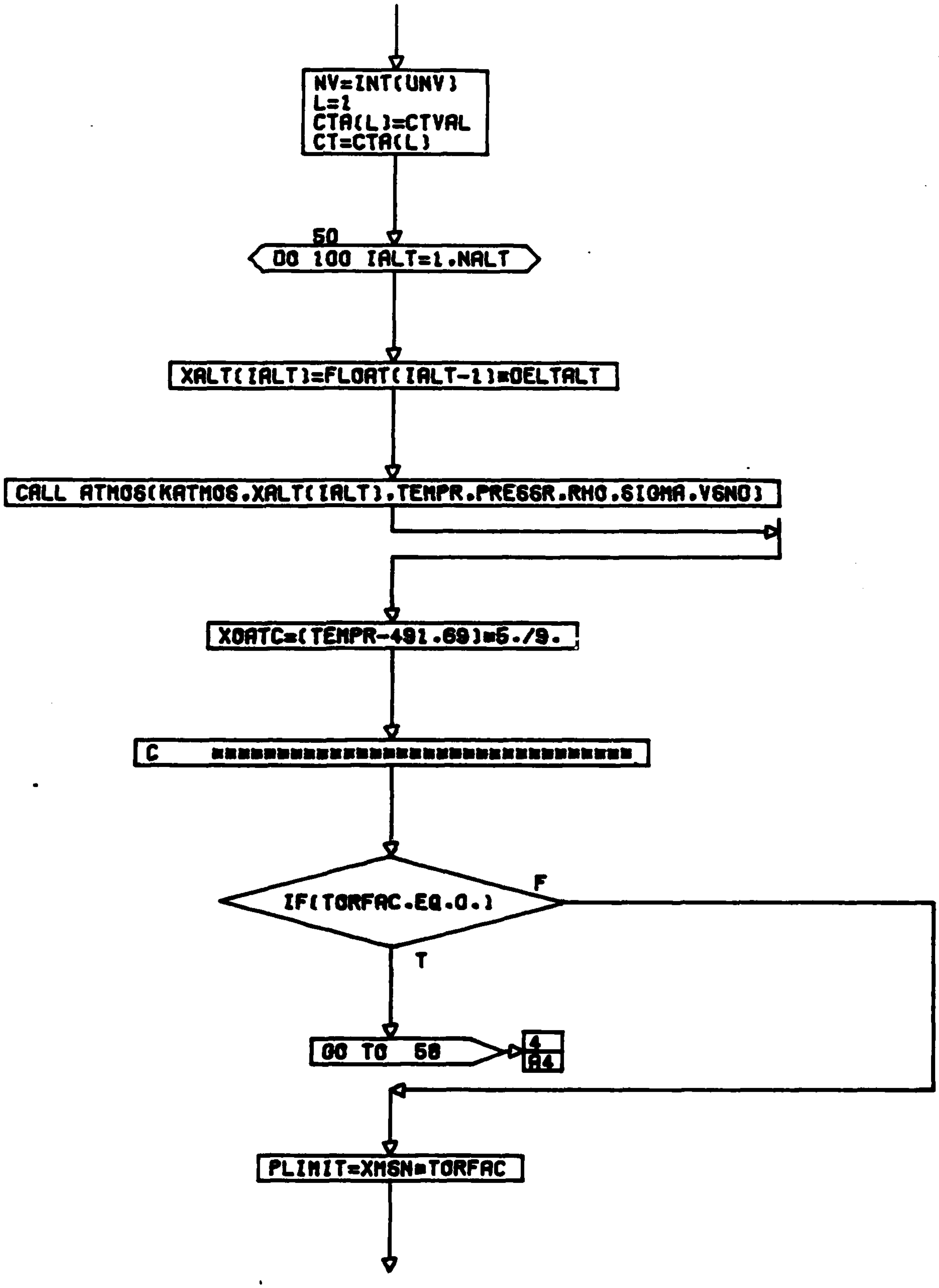
PG 10 FINAL

```
CSUSTURN

PROGRAM SUSTURN(INPUT.OUTPUT.TAPE5=INPUT.TAPE10.TAPE6.
TAPE8)

COMMON/PRINT/NPRINT
COMMON/IOUNITS/IP.IR.IO

DIMENSION CTA(100).PSIDOT(100.100).XTAS(100).XALT(100).
V(100).ITITLE(7).XCAS(100)

NAMELIST/D/NCAS.NALT.DELCAS.DELTALT.IATYPE.CPIRP.VTIP.UNV.
CAS1.ALT1.CTVAL.KATMOS.GFAC.TOGW.ADISK.TORFAC.PLIMIT.
ETAM.ETAP.DELFE.NPRINT.TMAN.TCHAR.MUCTSW.XMSN.
IPRINT.DELHP.CTMAX.TRVO.VB.NTRNRT.DELTRT.ALTO.
PSIMAX

DATA IP.IR.IO/10.5.10/
DATA TORFAC.PLIMIT.TMAN.TCHAR.MUCTSW/0..1.E6.0..1..0/
DATA ETAM.ETAP.DELFE/1..1..0./
DATA XMSN.IPRINT.G.DELHP/100..0.32.1741.0/
DATA PSIMAX/60./
READ(5.D)

IF(EOF(5))10.9        ≠
        0
  2
  A2
                A1  12
10
  STOP
```

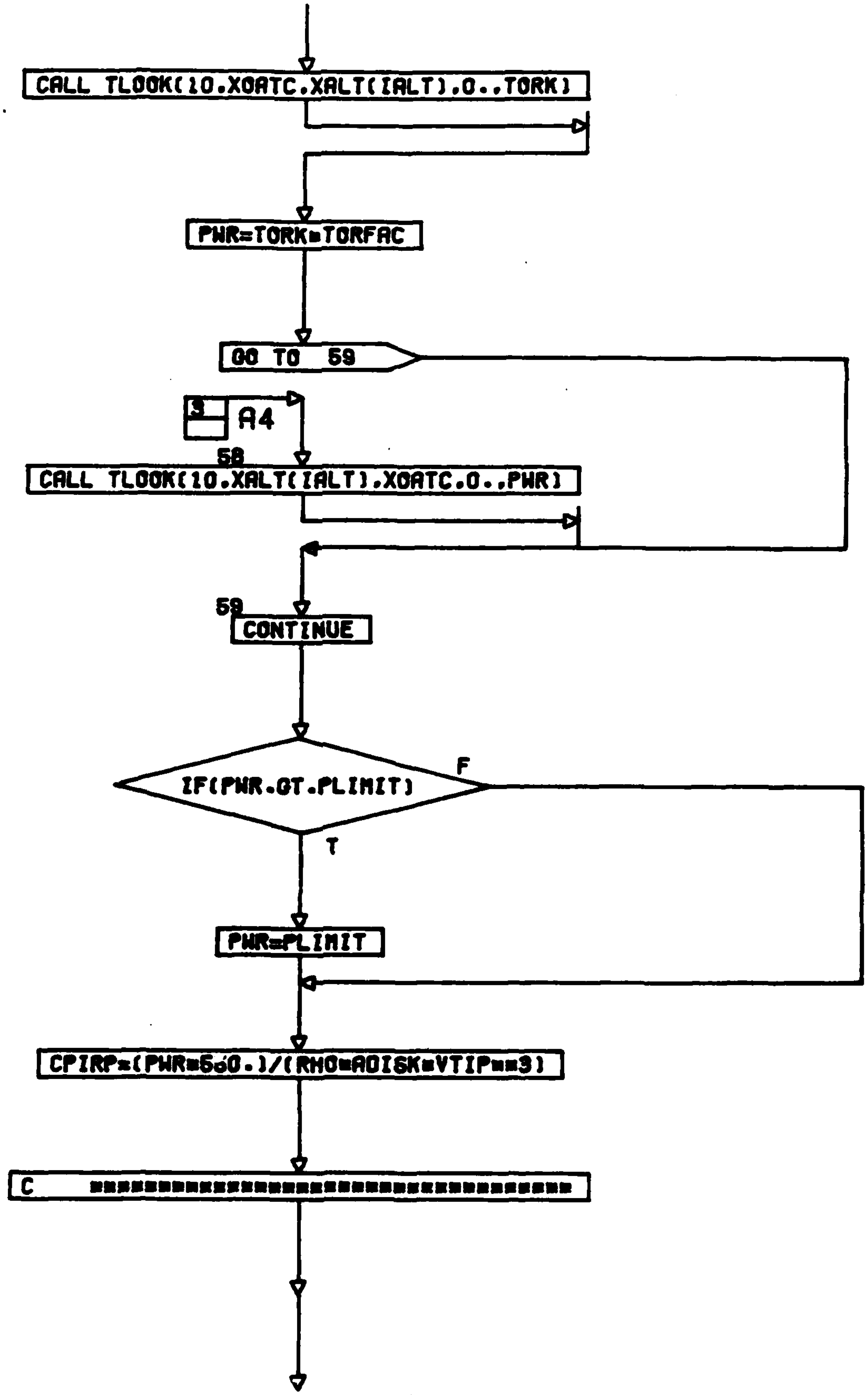
CONT. ON PG 2


1
A2
9
CONTINUE
READ(5.1)ITITLE
1
FORMAT(7A10) :
CALL TREAD(1.XD.YD.ZD.FXYZ)
A3
12
11
WRITE(8.2)ITITLE
PRINT(10.8)
IF(IPRINT.NE.0)
F
T
PRINT(10.*)"PSIDOT.G.MU.V.ALT.CT.CPI.RHO"
2
FORMAT(*ACZOA12*.7A10)
WRITE(8.*)NCAS.NALT.CAS1.DELCAS.ALT1.DELTALT.IATYPE

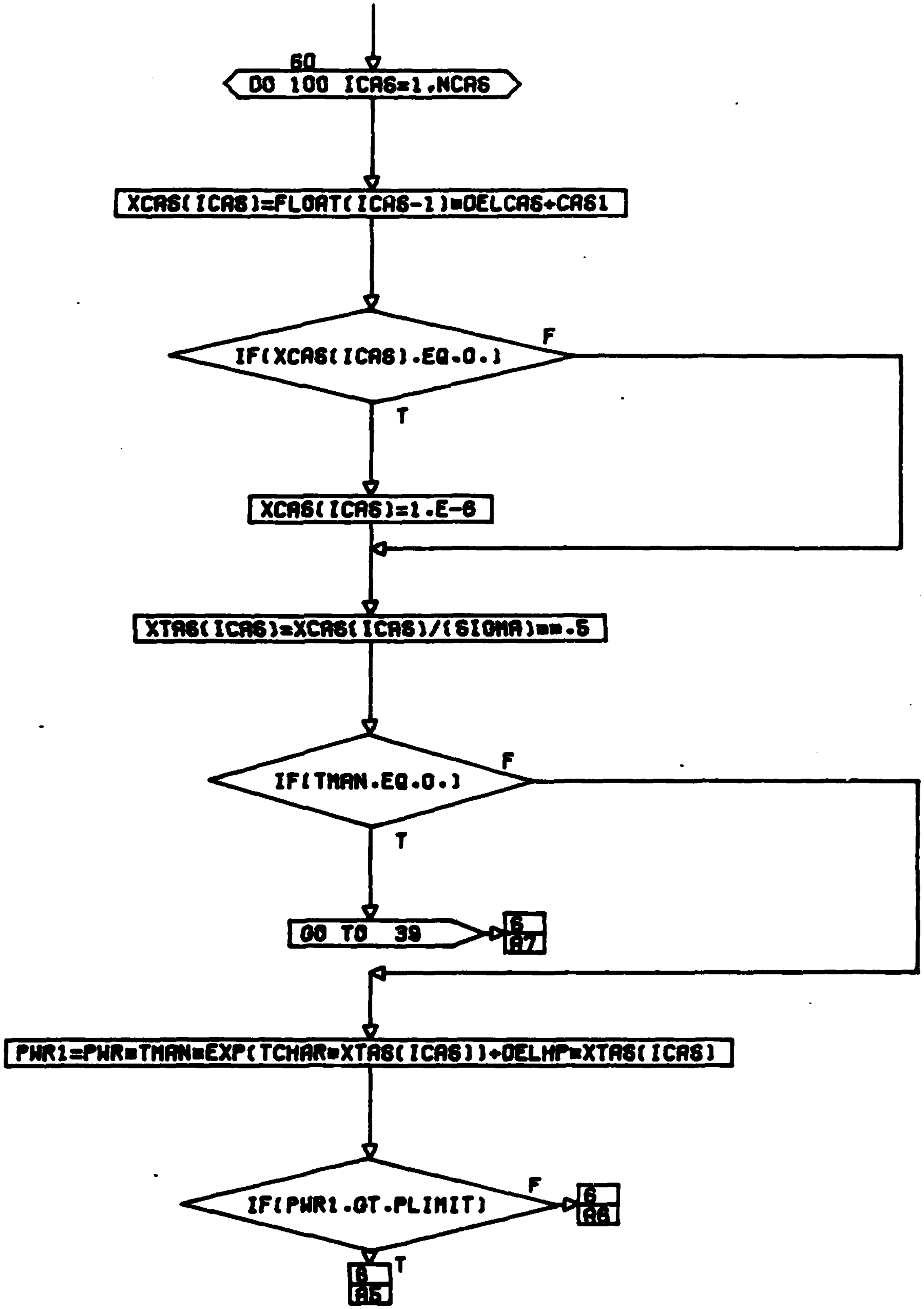
CONT. ON PG 3


NV=INT(UNV)
L=1
CTA(L)=CTVAL
CT=CTA(L)
50
DO 100 IALT=1,NALT
XALT(IALT)=FLOAT(IALT-1)*DELTALT
CALL ATMOS(KATMOS,XALT(IALT),TEMPR,PRESSR,RHO,SIGMA,VSND)
XOATC=(TEMPR-491.69)*5./9.
C ******************************
IF(TORFAC.EQ.0.)
F
T
GO TO 58
4
A4
PLIMIT=XMSN*TORFAC

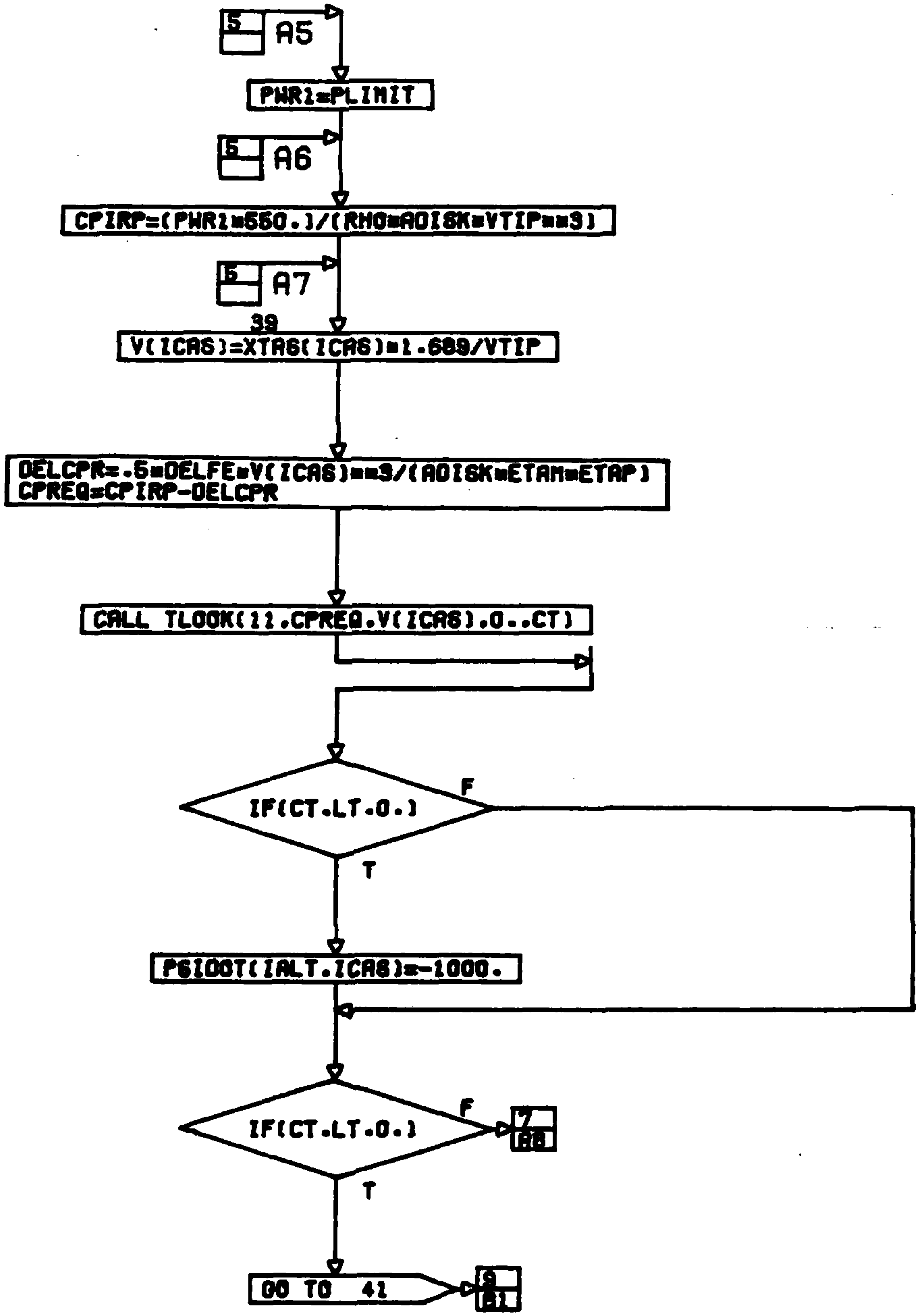
CONT. ON PG 4


CALL TLOOK(10.XOATC.XALT(IALT).0..TORK)
PWR=TORK*TORFAC
GO TO 59
3
A4
58
CALL TLOOK(10.XALT(IALT).XOATC.0..PWR)
59
CONTINUE
IF(PWR.GT.PLIMIT)
F
T
PWR=PLIMIT
CPIRP=(PWR*550.)/(RHO*ADISK*VTIP**3)
C ********************************

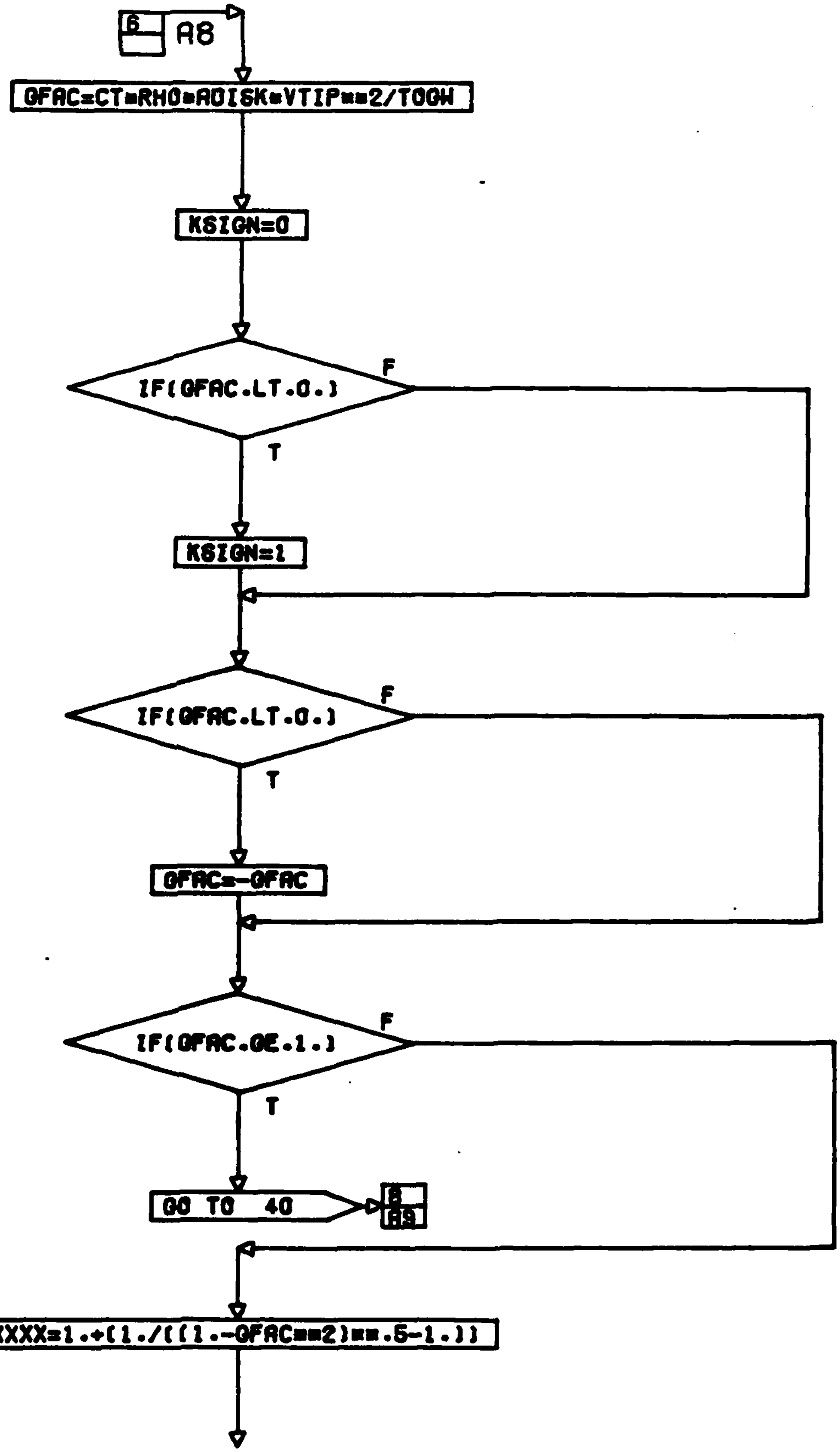
CONT. ON PG 5


60
DO 100 ICAS=1,NCAS
XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS+CAS1
IF(XCAS(ICAS).EQ.0.)
F
T
XCAS(ICAS)=1.E-6
XTAS(ICAS)=XCAS(ICAS)/(SIGMA)**.5
IF(TMAN.EQ.0.)
F
T
GO TO 39
6
A7
PWR1=PWR*TMAN*EXP(TCHAR*XTAS(ICAS))+DELHP*XTAS(ICAS)
IF(PWR1.GT.PLIMIT)
F
6
A6
T
6
A5

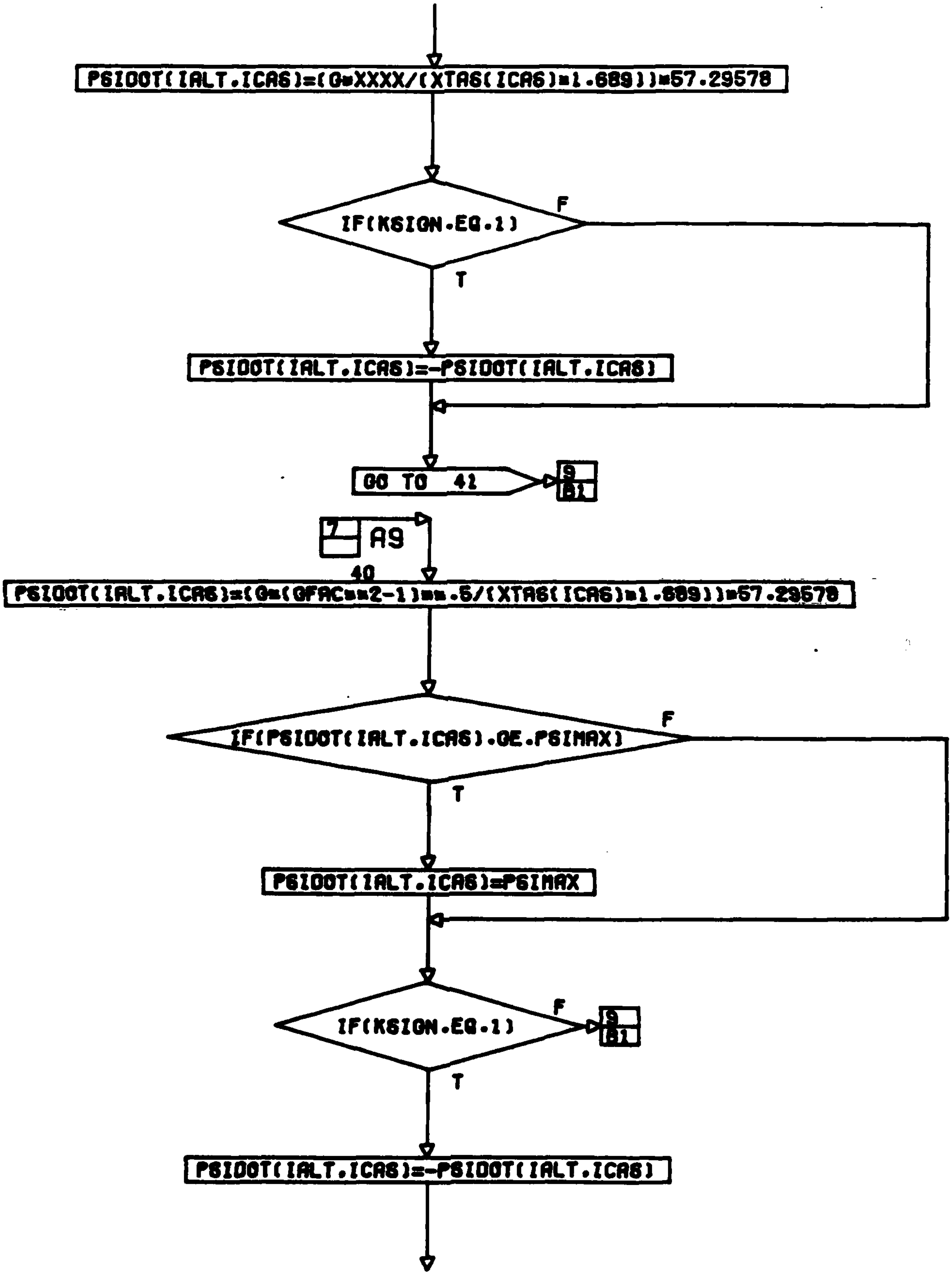
CONT. ON PG 6


5
A5
PWR1=PLIMIT
5
A6
CPIRP=(PWR1*550.)/(RHO*ADISK*VTIP**3)
5
A7
39
V(ICAS)=XTAS(ICAS)*1.689/VTIP
DELCPR=.5*DELFE*V(ICAS)**3/(ADISK*ETAM*ETAP)
CPREQ=CPIRP-DELCPR
CALL TLOOK(11,CPREQ,V(ICAS),0.,CT)
IF(CT.LT.0.)
F
T
PSIDOT(IALT,ICAS)=-1000.
IF(CT.LT.0.)
F
7
A8
T
GO TO 41
9
B1

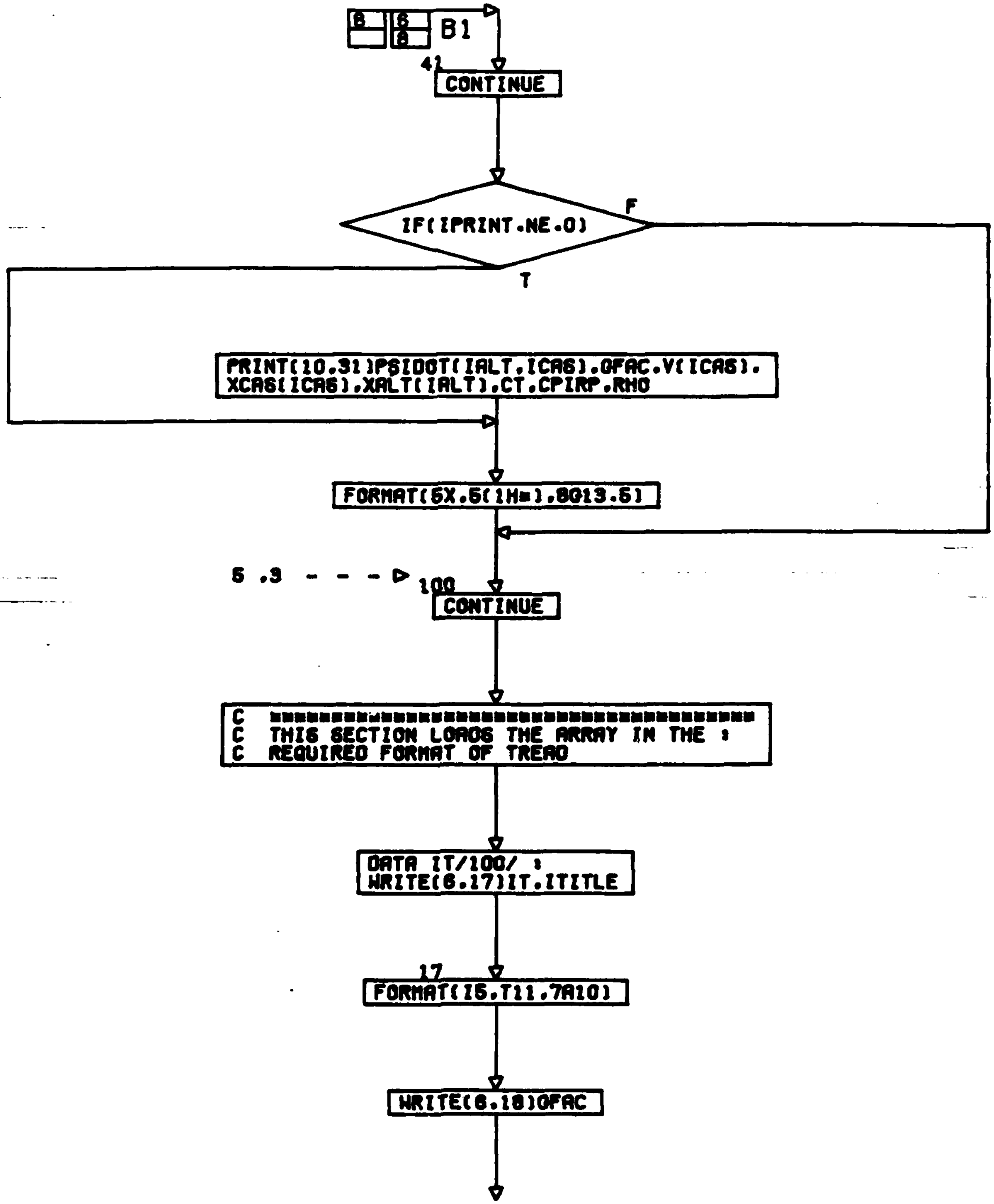
CONT. ON PG 7


6
A8
GFAC=CT*RHO*ADISK*VTIP**2/TOGW
KSIGN=0
IF(GFAC.LT.0.)
F
T
KSIGN=1
IF(GFAC.LT.0.)
F
T
GFAC=-GFAC
IF(GFAC.GE.1.)
F
T
GO TO 40
8
A9
XXXX=1.+(1./((1.-GFAC**2)**.5-1.))

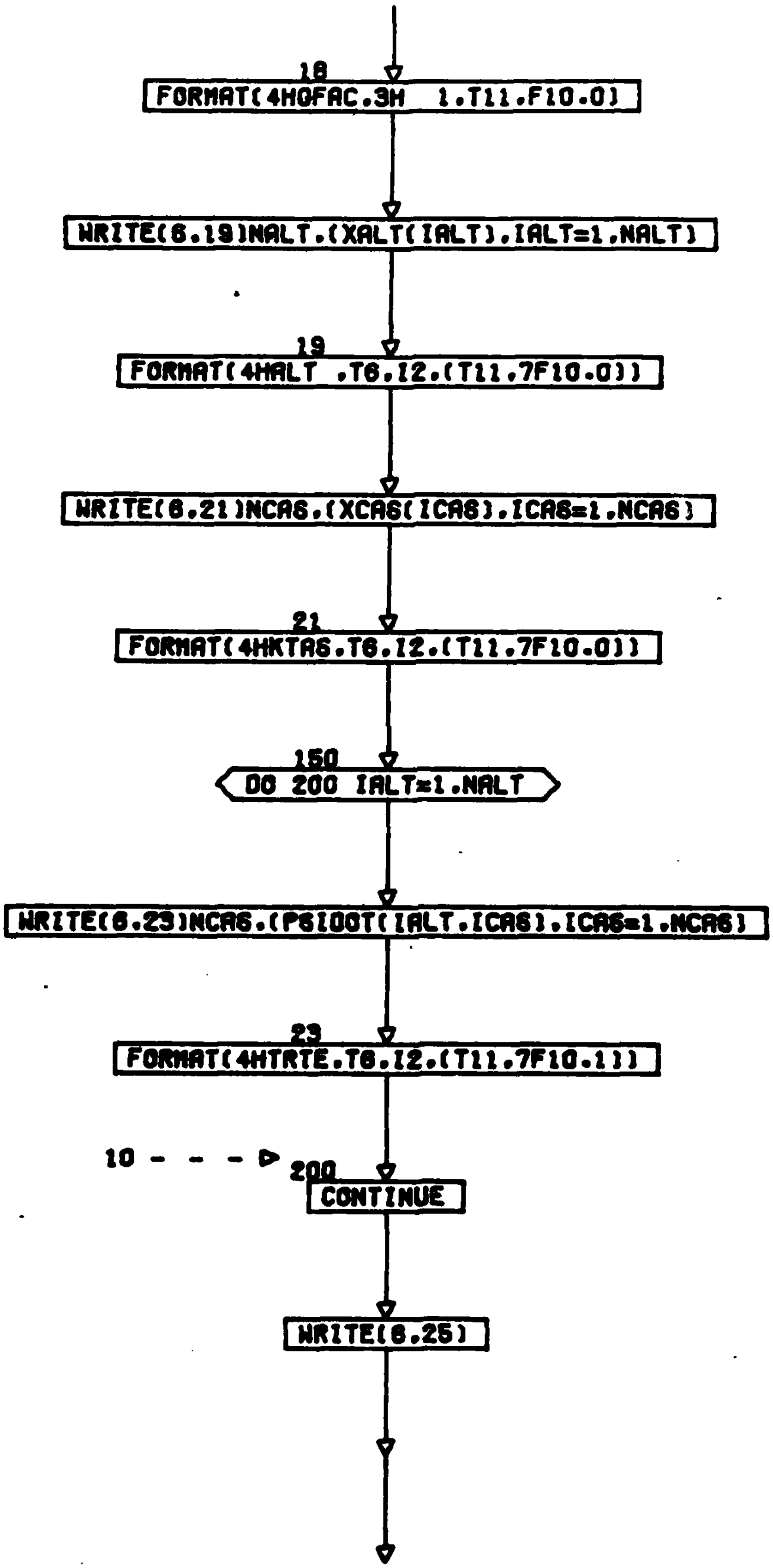
CONT. ON PG 8


PSIDOT(IALT.ICAS)=(G*XXXX/(XTAS(ICAS)*1.689))*57.29578
IF(KSIGN.EQ.1)
F
T
PSIDOT(IALT.ICAS)=-PSIDOT(IALT.ICAS)
GO TO 41
9
B1
7
A9
40
PSIDOT(IALT.ICAS)=(G*(GFAC**2-1)**.5/(XTAS(ICAS)*1.689))*57.29578
IF(PSIDOT(IALT.ICAS).GE.PSIMAX)
F
T
PSIDOT(IALT.ICAS)=PSIMAX
IF(KSIGN.EQ.1)
F
9
B1
T
PSIDOT(IALT.ICAS)=-PSIDOT(IALT.ICAS)

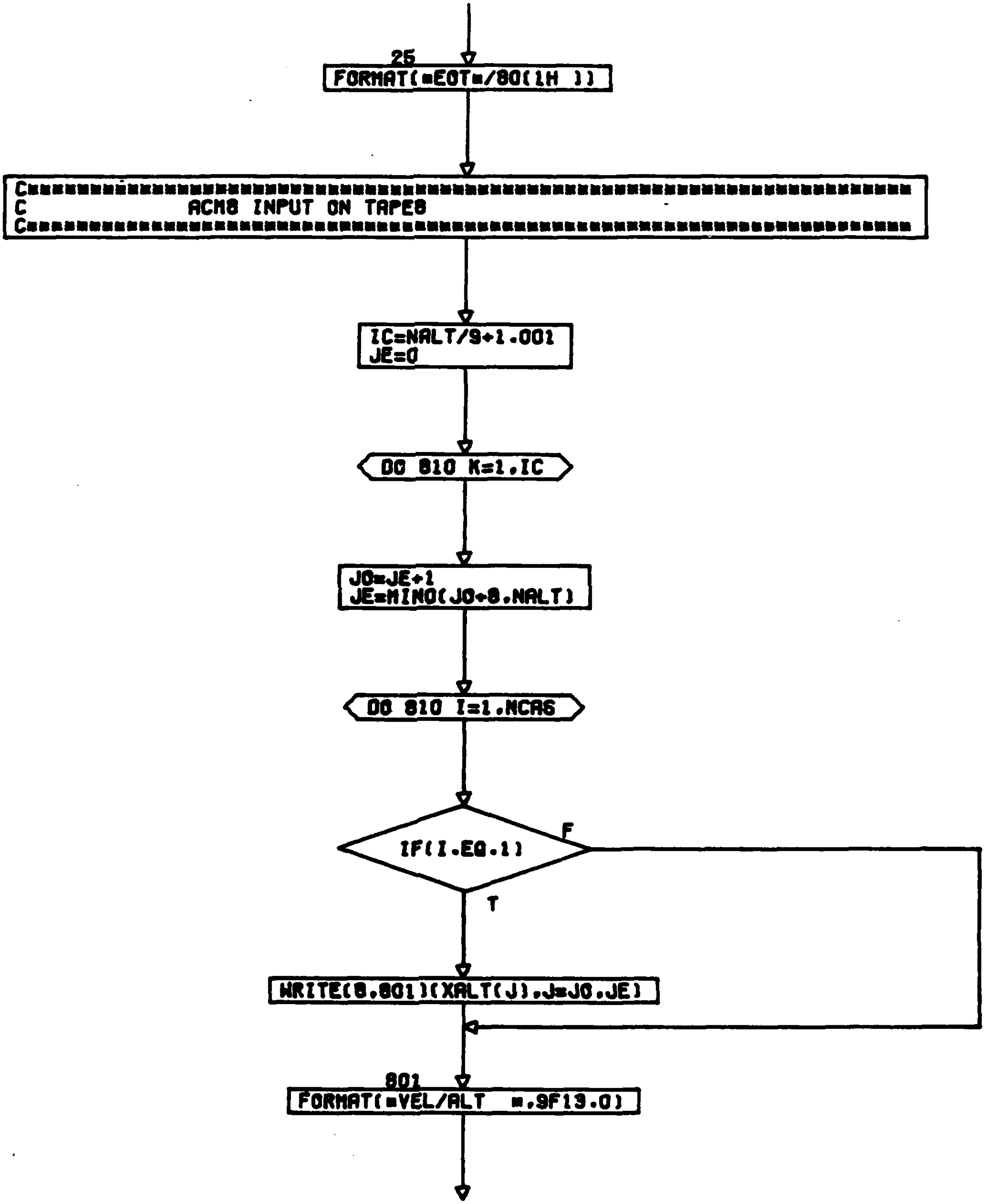
CONT. ON PG 9


B
6
8
B1
41
CONTINUE
IF(IPRINT.NE.0)
F
T
PRINT(10,31)PSIDOT(IALT,ICAS),GFAC,V(ICAS),
XCAS(ICAS),XALT(IALT),CT,CPIRP,RHO
FORMAT(5X,5(1H*),8G13.5)
5 ,3
100
CONTINUE
C **
C THIS SECTION LOADS THE ARRAY IN THE :
C REQUIRED FORMAT OF TREAD
DATA IT/100/ :
WRITE(6,17)IT,ITITLE
17
FORMAT(I5,T11,7A10)
WRITE(6,18)GFAC

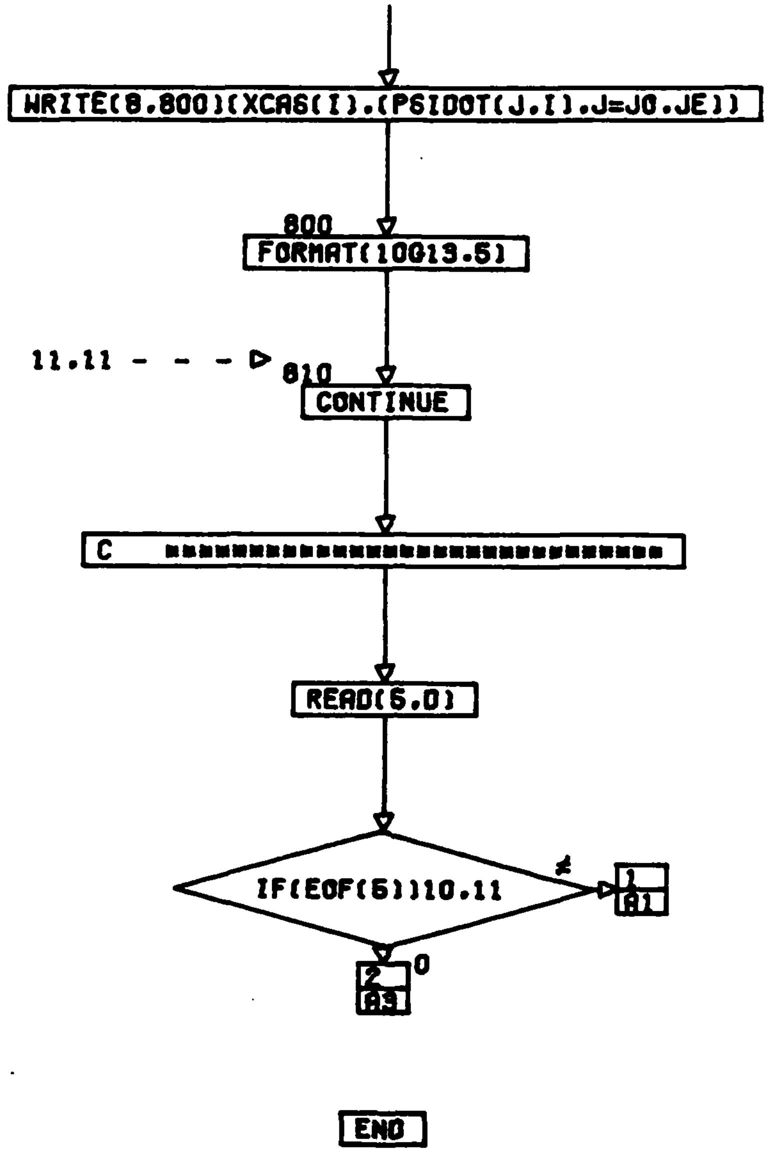
CONT. ON PG 10


18
FORMAT(4HGFAC.3H 1.T11.F10.0)
WRITE(6.19)NALT.(XALT(IALT).IALT=1.NALT)
19
FORMAT(4HALT .T6.I2.(T11.7F10.0))
WRITE(6.21)NCAS.(XCAS(ICAS).ICAS=1.NCAS)
21
FORMAT(4HKTAS.T6.I2.(T11.7F10.0))
150
DO 200 IALT=1.NALT
WRITE(6.23)NCAS.(PSIDOT(IALT.ICAS).ICAS=1.NCAS)
23
FORMAT(4HTRTE.T6.I2.(T11.7F10.1))
10
200
CONTINUE
WRITE(6.25)

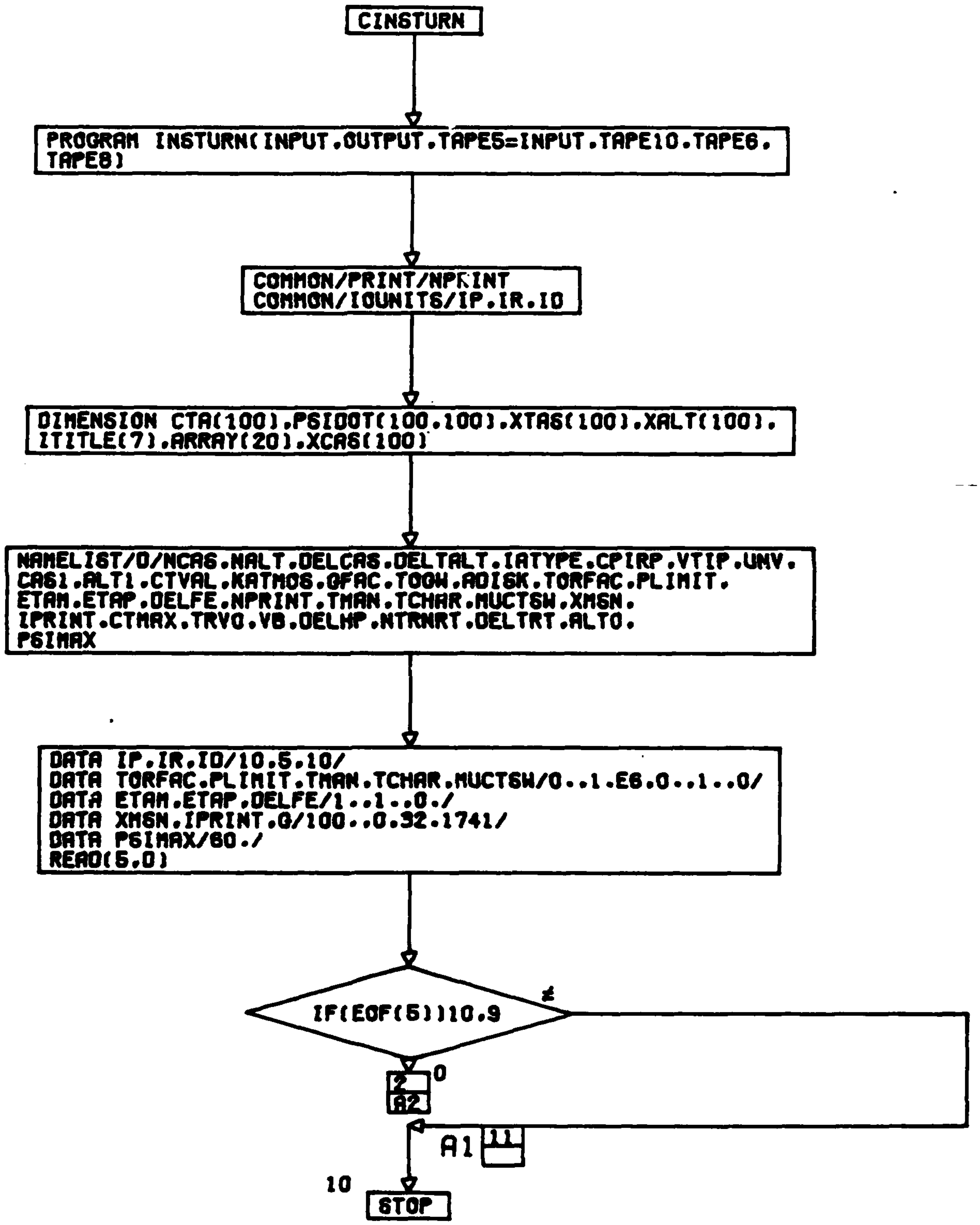
CONT. ON PG 11


25
FORMAT(*EOT*/80(1H))
C**
C ACM8 INPUT ON TAPE8
C**
IC=NALT/9+1.001
JE=0
DO 810 K=1,IC
JO=JE+1
JE=MINO(JO+8,NALT)
DO 810 I=1,NCAS
IF(I.EQ.1)
F
T
WRITE(8,801)(XALT(J),J=JO,JE)
801
FORMAT(*VEL/ALT *,9F13.0)

CONT. ON PG 12


WRITE(8,800)(XCAS(I),(PSIDOT(J,I),J=JB,JE))
800
FORMAT(10G13.5)
11.11
810
CONTINUE
C
READ(5,0)
IF(EOF(5))10,11
≠
1
A1
0
2
A3
END

PG 12 FINAL


CINSTURN
PROGRAM INSTURN(INPUT.OUTPUT.TAPE5=INPUT.TAPE10.TAPE6.
TAPE8)
COMMON/PRINT/NPRINT
COMMON/IOUNITS/IP.IR.IO
DIMENSION CTA(100).PSIDOT(100.100).XTAS(100).XALT(100).
ITITLE(7).ARRAY(20).XCAS(100)
NAMELIST/D/NCAS.NALT.DELCAS.DELTALT.IATYPE.CPIRP.VTIP.UNV.
CAS1.ALT1.CTVAL.KATMOS.GFAC.TOGW.ADISK.TORFAC.PLIMIT.
ETAM.ETAP.DELFE.NPRINT.TMAN.TCHAR.MUCTSW.XMSN.
IPRINT.CTMAX.TRVQ.VB.DELHP.NTRNRT.DELTRT.ALTO.
PSIMAX
DATA IP.IR.IO/10.5.10/
DATA TORFAC.PLIMIT.TMAN.TCHAR.MUCTSW/0..1.E6.0..1..0/
DATA ETAM.ETAP.DELFE/1..1..0./
DATA XMSN.IPRINT.G/100..0.32.1741/
DATA PSIMAX/60./
READ(5.D)
IF(EOF(5))10.9
≠
0
2
A2
A1
11
10
STOP

CONT. ON PG 2

AD-A124 603 HELICOPTER PERFORMANCE COMPUTER PROGRAMS(U) NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA AIRCRAFT AND CREW SYSTEMS TECHNOLOGY DIRECTORATE D KOBUS ET AL. 2/2

UNCLASSIFIED 30 OCT 82 F/G 9/2 NL

END

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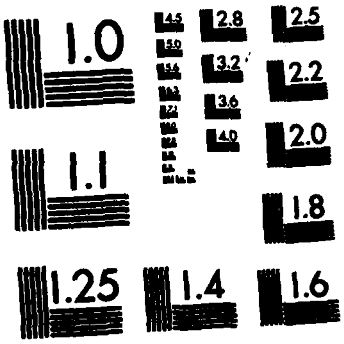
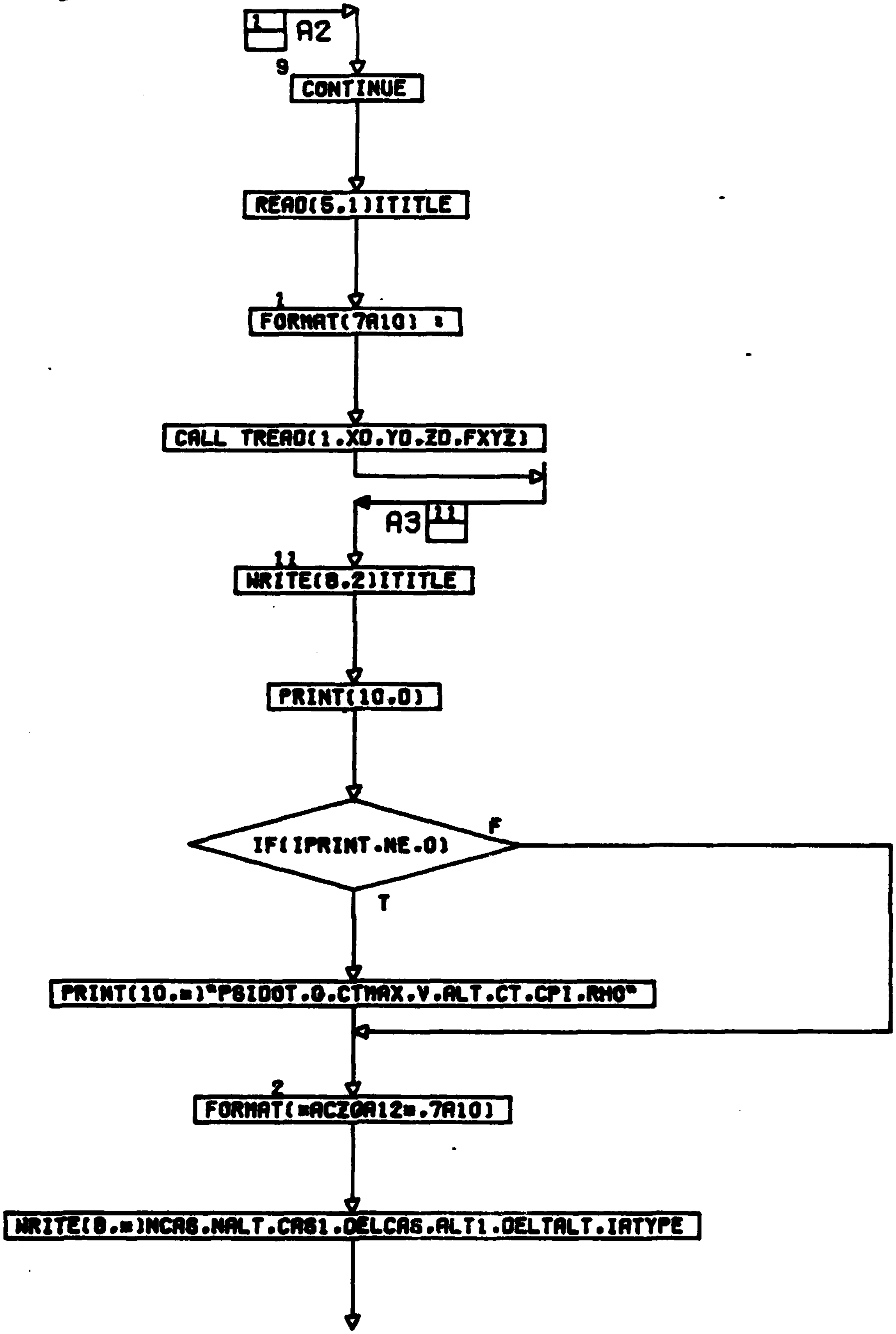
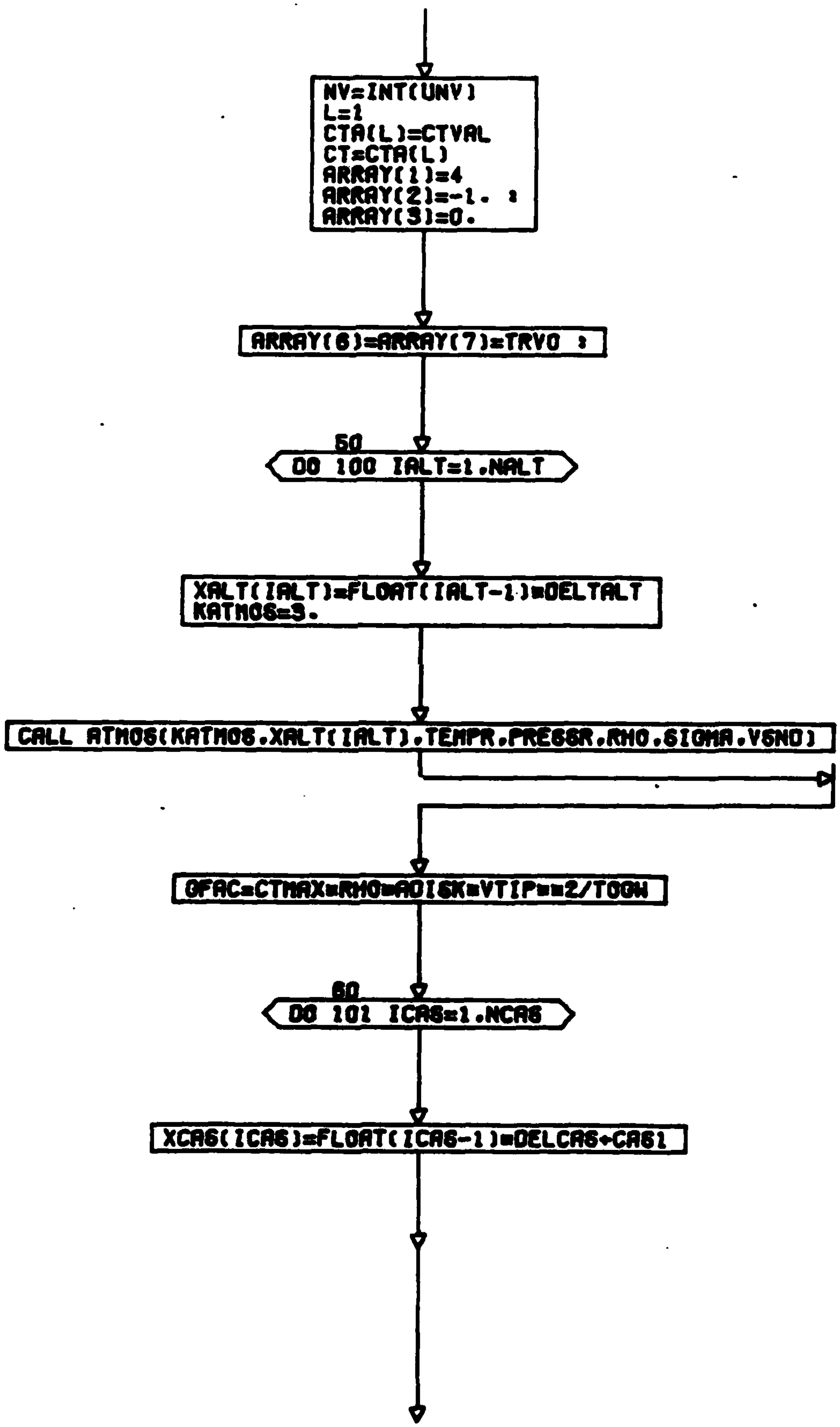
DTIC



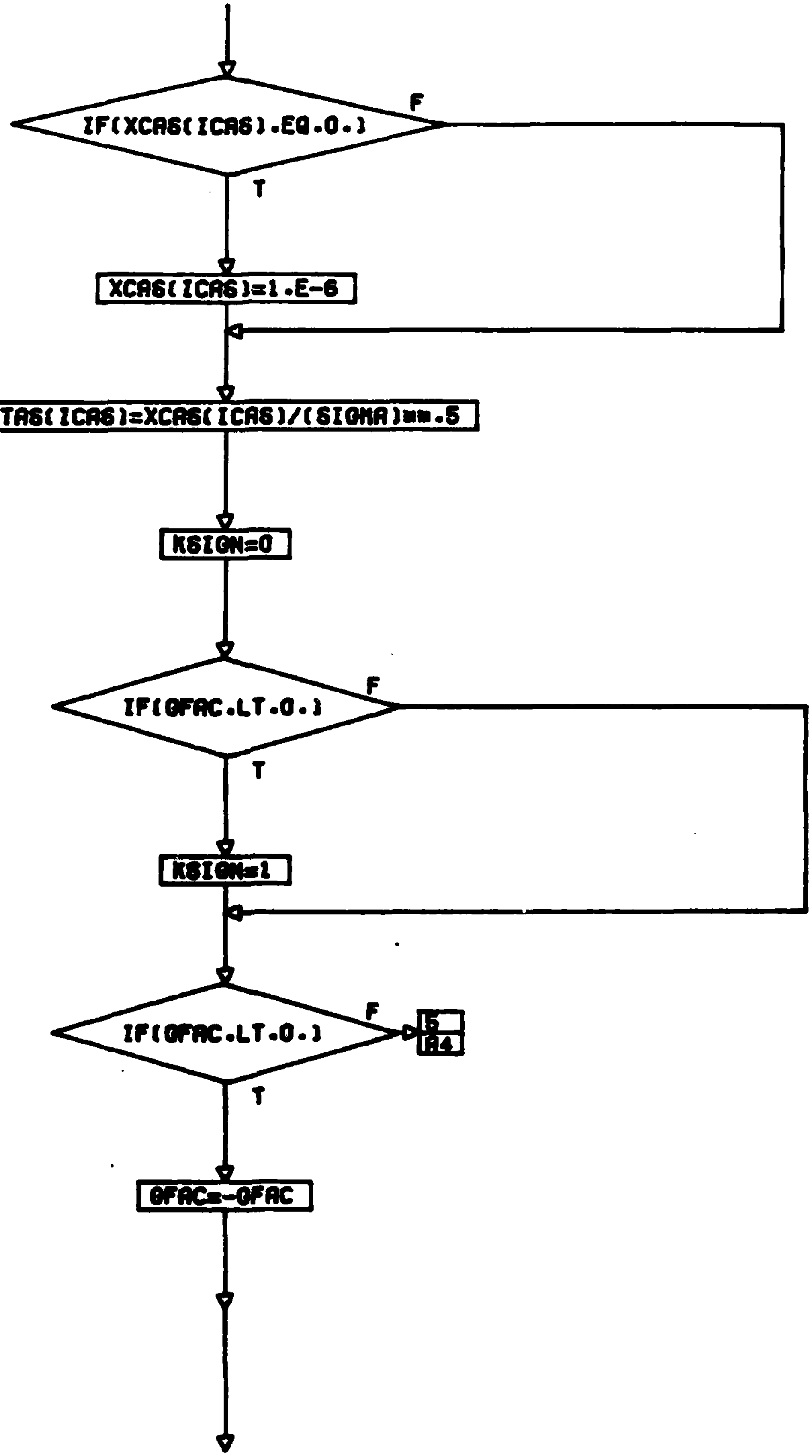
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A


1
A2
9
CONTINUE
READ(5,1)ITITLE
1
FORMAT(7A10) :
CALL TREAD(1,XD,YD,ZD,FXYZ)
A3
11
11
WRITE(8,2)ITITLE
PRINT(10,0)
IF(IPRINT.NE.0)
F
T
PRINT(10,*)"PSIDOT,G,CTMAX,V,ALT,CT,CPI,RHO"
2
FORMAT(*ACZOA12*,7A10)
WRITE(8,*)NCAS,NALT,CAS1,DELCAS,ALT1,DELTALT,IATYPE

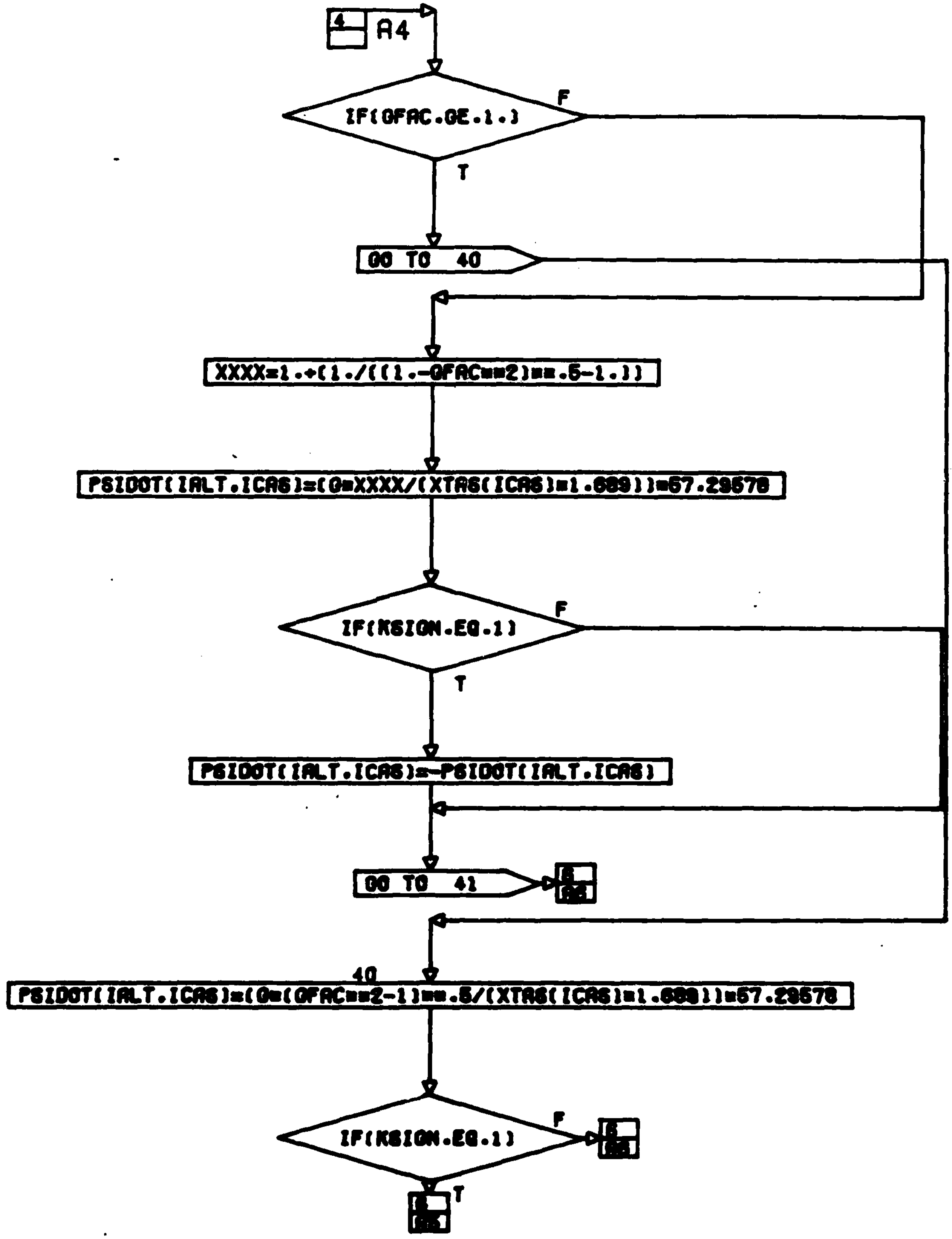
CONT. ON PG 9


NV=INT(UNV)
L=1
CTA(L)=CTVAL
CT=CTA(L)
ARRAY(1)=4
ARRAY(2)=-1. :
ARRAY(3)=0.
ARRAY(6)=ARRAY(7)=TRVO :
50
DO 100 IALT=1,NALT
XALT(IALT)=FLOAT(IALT-1)*DELTALT
KATMOS=3.
CALL ATMOS(KATMOS,XALT(IALT),TEMPR,PRESSR,RHO,SIGMA,VSND)
GFAC=CTMAX*RHO*ADISK*VTIP**2/TOGW
60
DO 101 ICAS=1,NCAS
XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS+CAS1

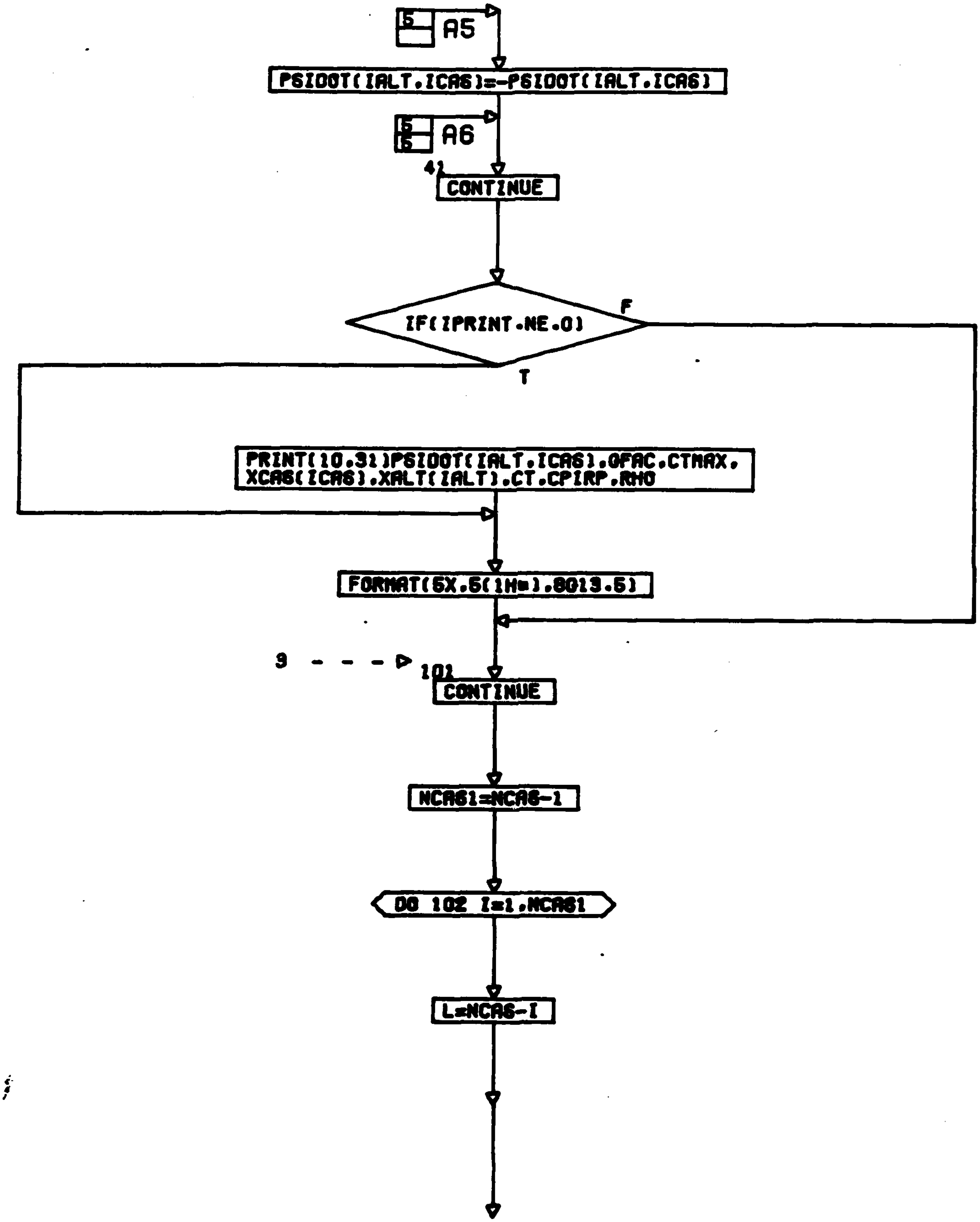
CONT. ON PG 4


IF(XCAS(ICAS).EQ.0.)
F
T
XCAS(ICAS)=1.E-6
XTAS(ICAS)=XCAS(ICAS)/(SIGMA)**.5
KSIGN=0
IF(GFAC.LT.0.)
F
T
KSIGN=1
IF(GFAC.LT.0.)
F
5
A4
T
GFAC=-GFAC

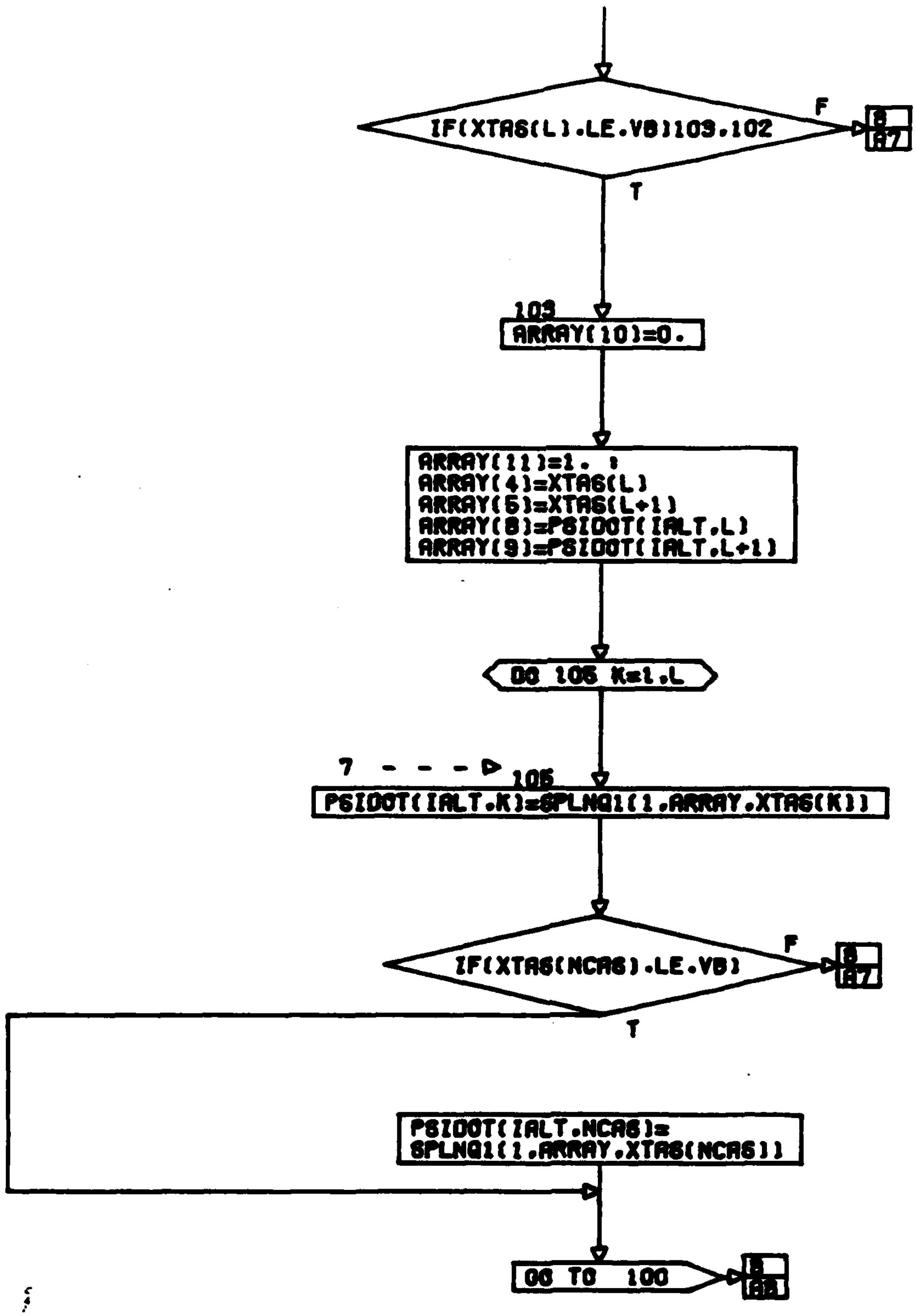
CONT. ON PG 5


4
A4
IF(GFAC.GE.1.)
F
T
GO TO 40
XXXX=1.+(1./((1.-GFAC**2)**.5-1.))
PSIDOT(IALT.ICAS)=(G*XXXX/(XTAS(ICAS)*1.689))*57.29578
IF(KSIGN.EQ.1)
F
T
PSIDOT(IALT.ICAS)=-PSIDOT(IALT.ICAS)
GO TO 41
40
PSIDOT(IALT.ICAS)=(G*(GFAC**2-1)**.5/(XTAS(ICAS)*1.689))*57.29578
IF(KSIGN.EQ.1)
F
T

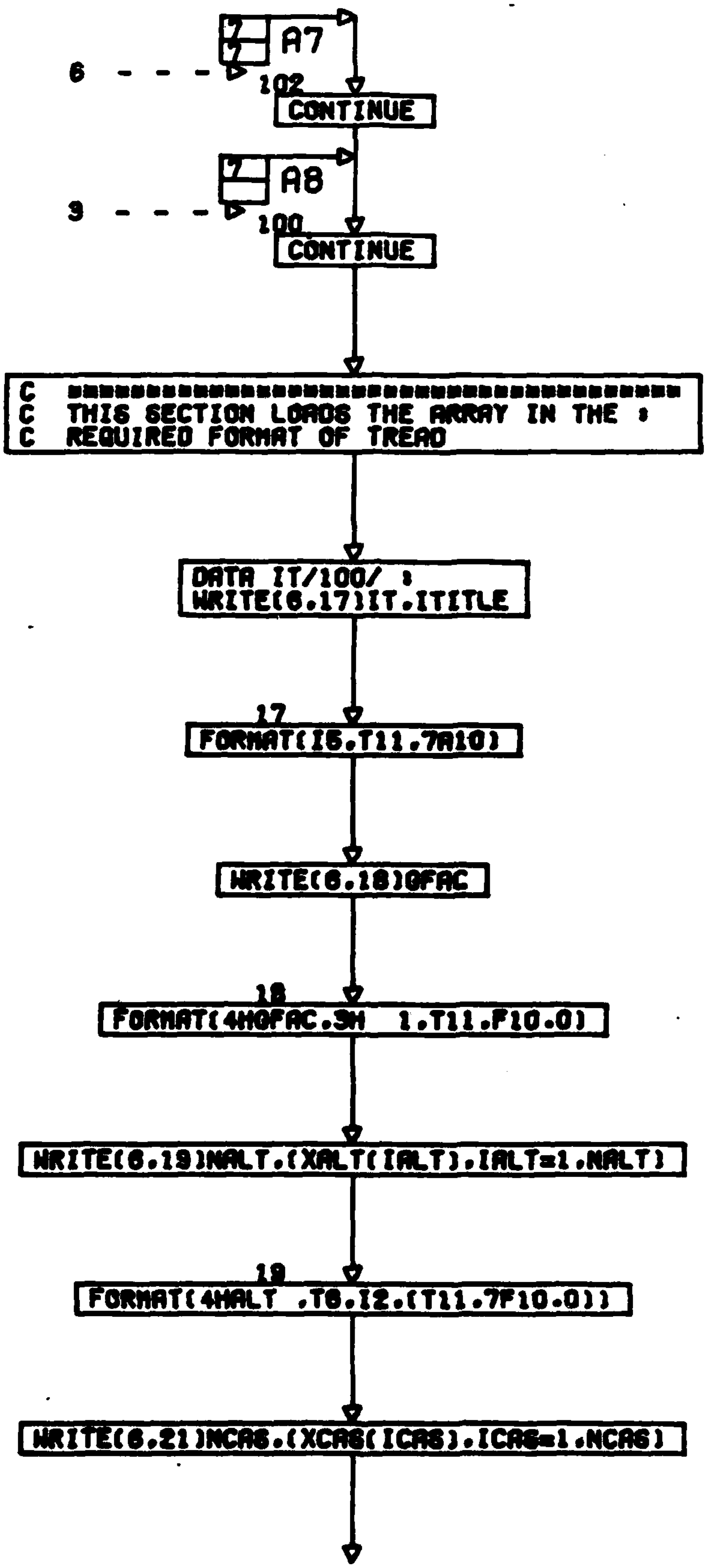
CONT. ON PG 6


5
A5
PSIDOT(IALT,ICAS)=-PSIDOT(IALT,ICAS)
5
5
A6
41
CONTINUE
IF(IPRINT.NE.0)
F
T
PRINT(10,31)PSIDOT(IALT,ICAS),GFAC,CTMAX,
XCAS(ICAS),XALT(IALT),CT,CPIRP,RHO
FORMAT(5X,5(1H=),8G13.5)
9
101
CONTINUE
NCAS1=NCAS-1
DO 102 I=1,NCAS1
L=NCAS-I

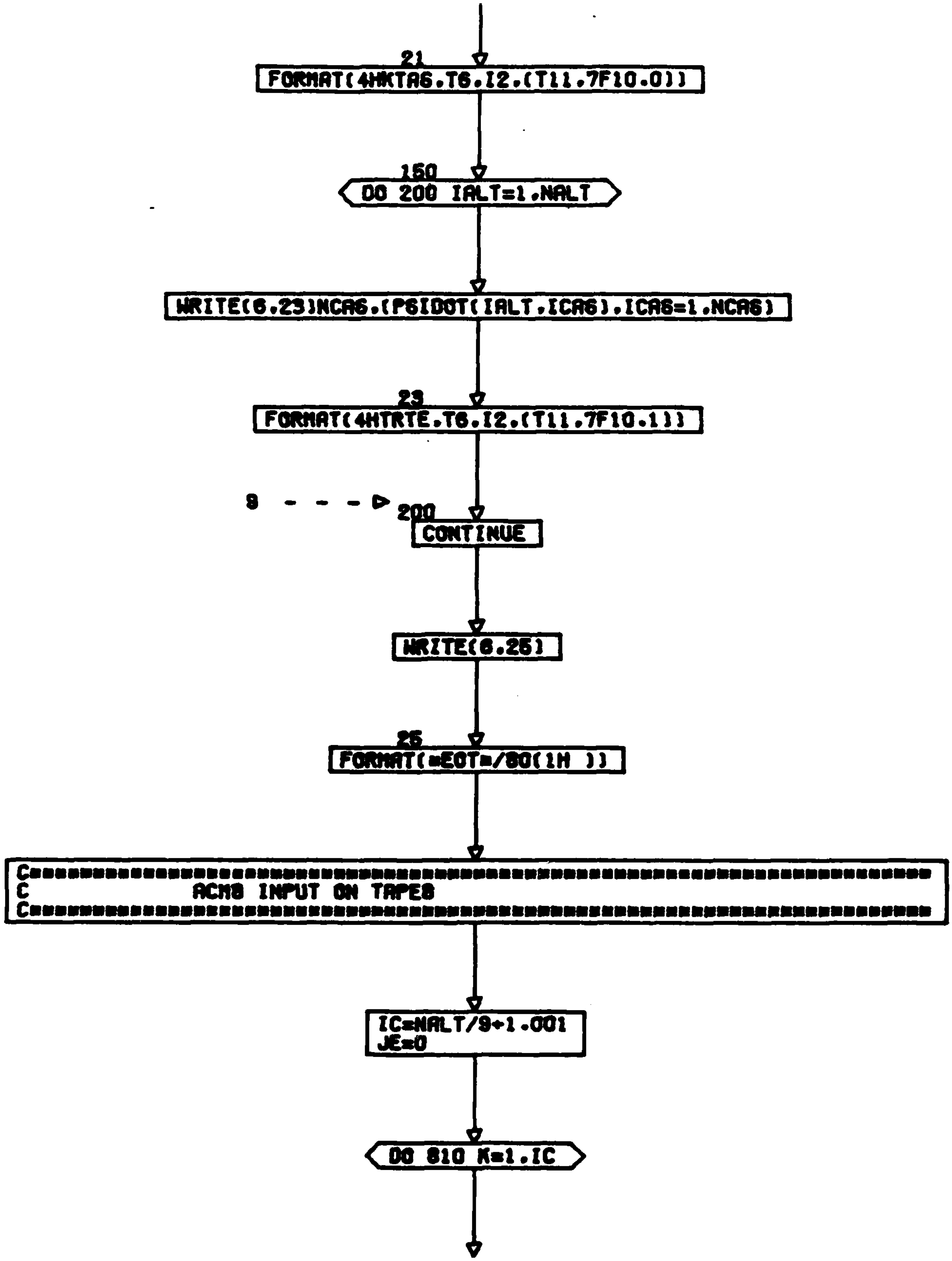
CONT. ON PG 7


IF(XTAS(L).LE.VB)103.102
F
8
A7
T
103
ARRAY(10)=0.
ARRAY(11)=1. ;
ARRAY(4)=XTAS(L)
ARRAY(5)=XTAS(L+1)
ARRAY(8)=PSIDOT(IALT.L)
ARRAY(9)=PSIDOT(IALT.L+1)
DO 105 K=1.L
7 - - - ▷
105
PSIDOT(IALT.K)=SPLNQ1(1.ARRAY.XTAS(K))
IF(XTAS(NCAS).LE.VB)
F
8
A7
T
PSIDOT(IALT.NCAS)=
SPLNQ1(1.ARRAY.XTAS(NCAS))
GO TO 100
8
A5

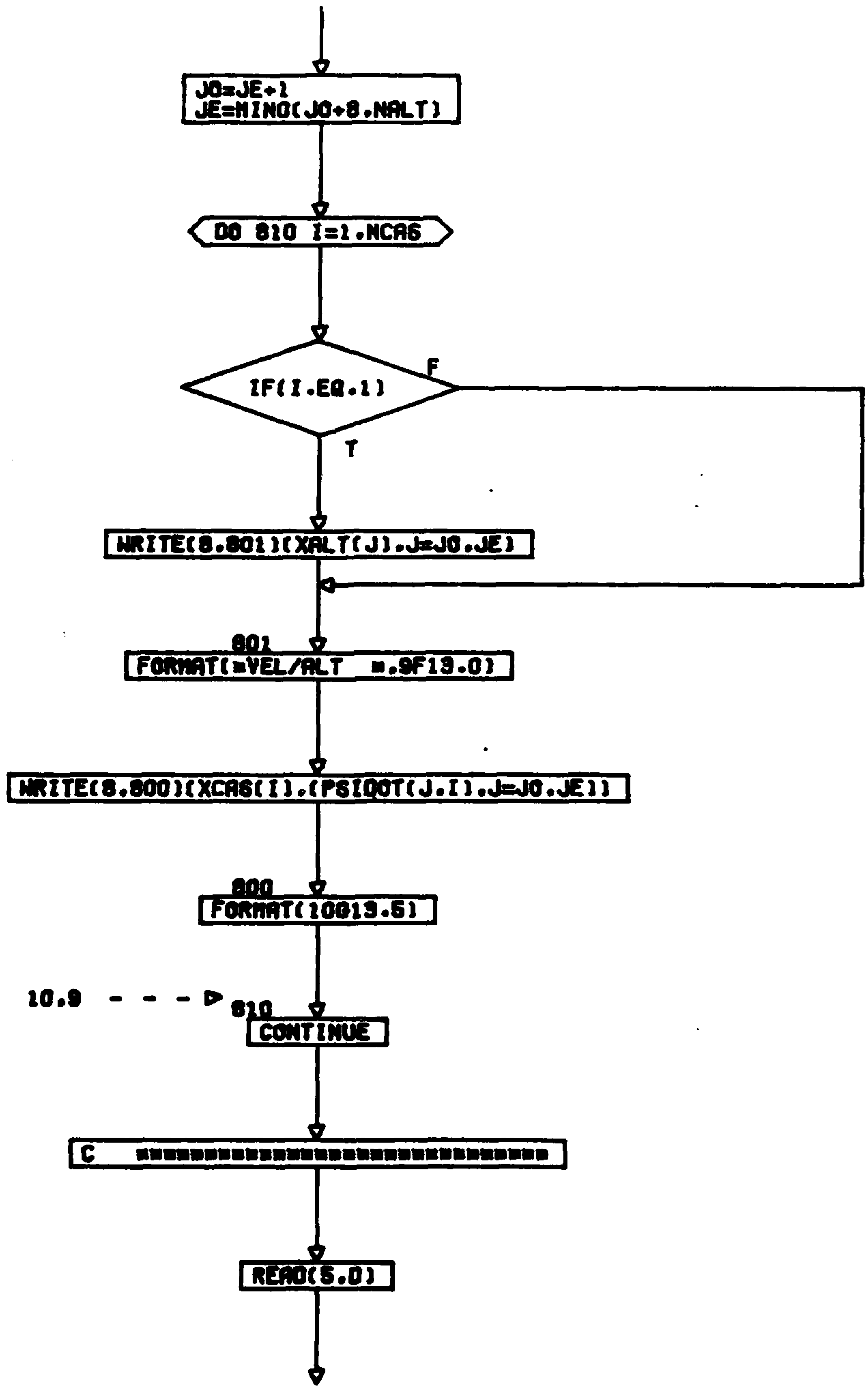
CONT. ON PG 8


A7
6
102
CONTINUE
A8
9
100
CONTINUE
C ************************************
C THIS SECTION LOADS THE ARRAY IN THE :
C REQUIRED FORMAT OF TREAD
DATA IT/100/ :
WRITE(6,17)IT,ITITLE
17
FORMAT(I5,T11,7A10)
WRITE(6,18)GFAC
18
FORMAT(4HGFAC,3H),T11,F10.0)
WRITE(6,19)NALT,(XALT(IALT),IALT=1,NALT)
19
FORMAT(4HALT ,T6,I2,(T11,7F10.0))
WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)

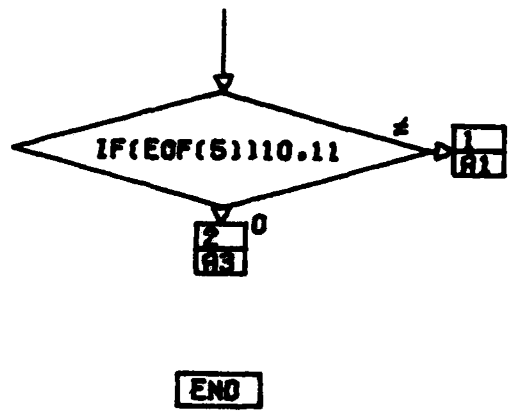
CONT. ON PG 9


21
FORMAT(4HKTAS,T6,I2,(T11,7F10.0))
150
DO 200 IALT=1,NALT
WRITE(6,23)NCAS,(PSIDOT(IALT,ICAS),ICAS=1,NCAS)
23
FORMAT(4HTRTE,T6,I2,(T11,7F10.1))
8
200
CONTINUE
WRITE(6,25)
25
FORMAT(*EOT*/80(1H))
C**
C ACMS INPUT ON TAPES
C**
IC=NALT/9+1.001
JE=0
DO 810 K=1,IC

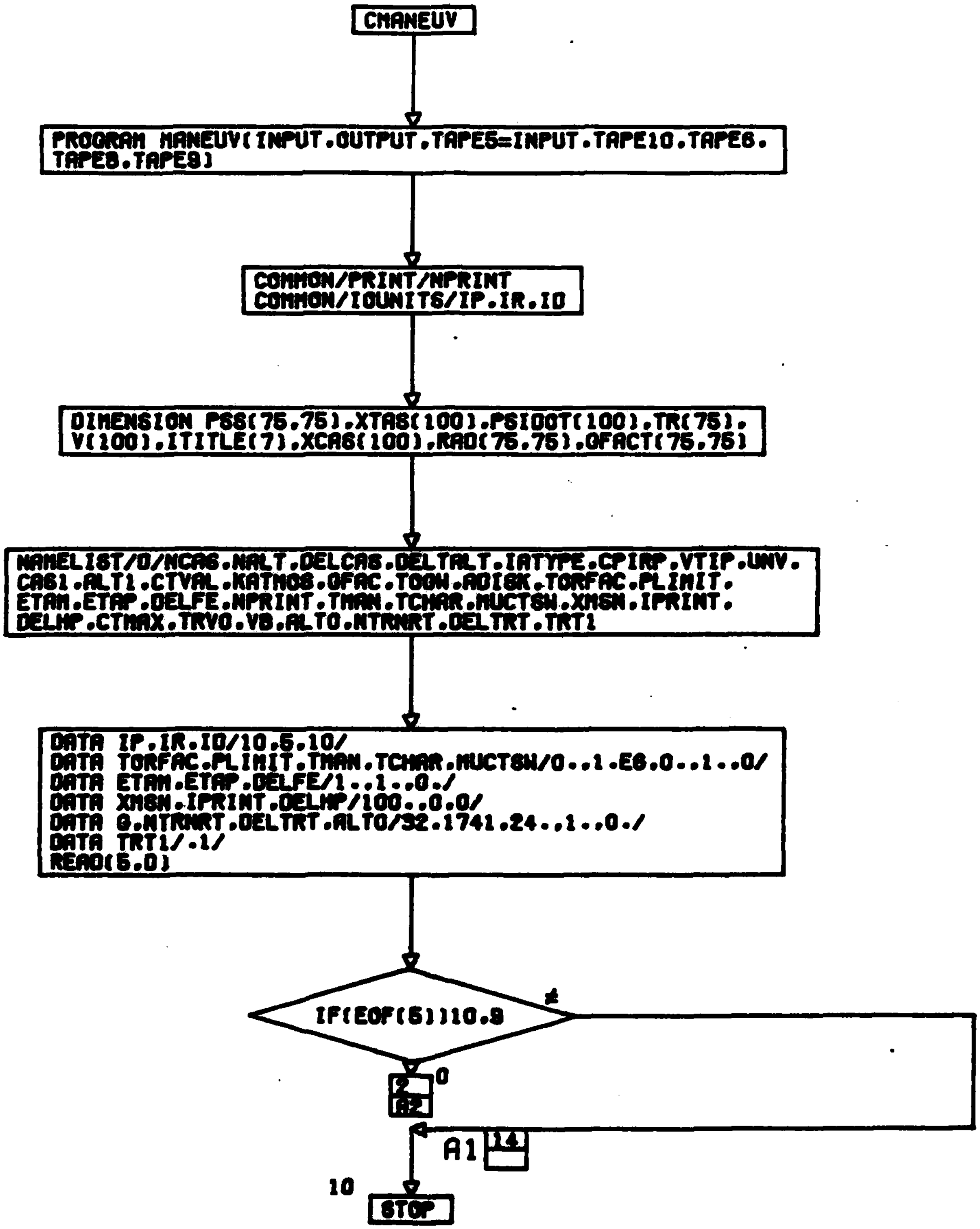
CONT. ON PG 10


JO=JE+1
JE=MINO(JO+8,NALT)
DO 810 I=1,NCAS
IF(I.EQ.1)
F
T
WRITE(8,801)(XALT(J),J=JO,JE)
801
FORMAT(=VEL/ALT =,9F13.0)
WRITE(8,800)(XCAS(I),(PSIDOT(J,I),J=JO,JE))
800
FORMAT(10G13.5)
10.9
810
CONTINUE
C ******************************
READ(5,0)

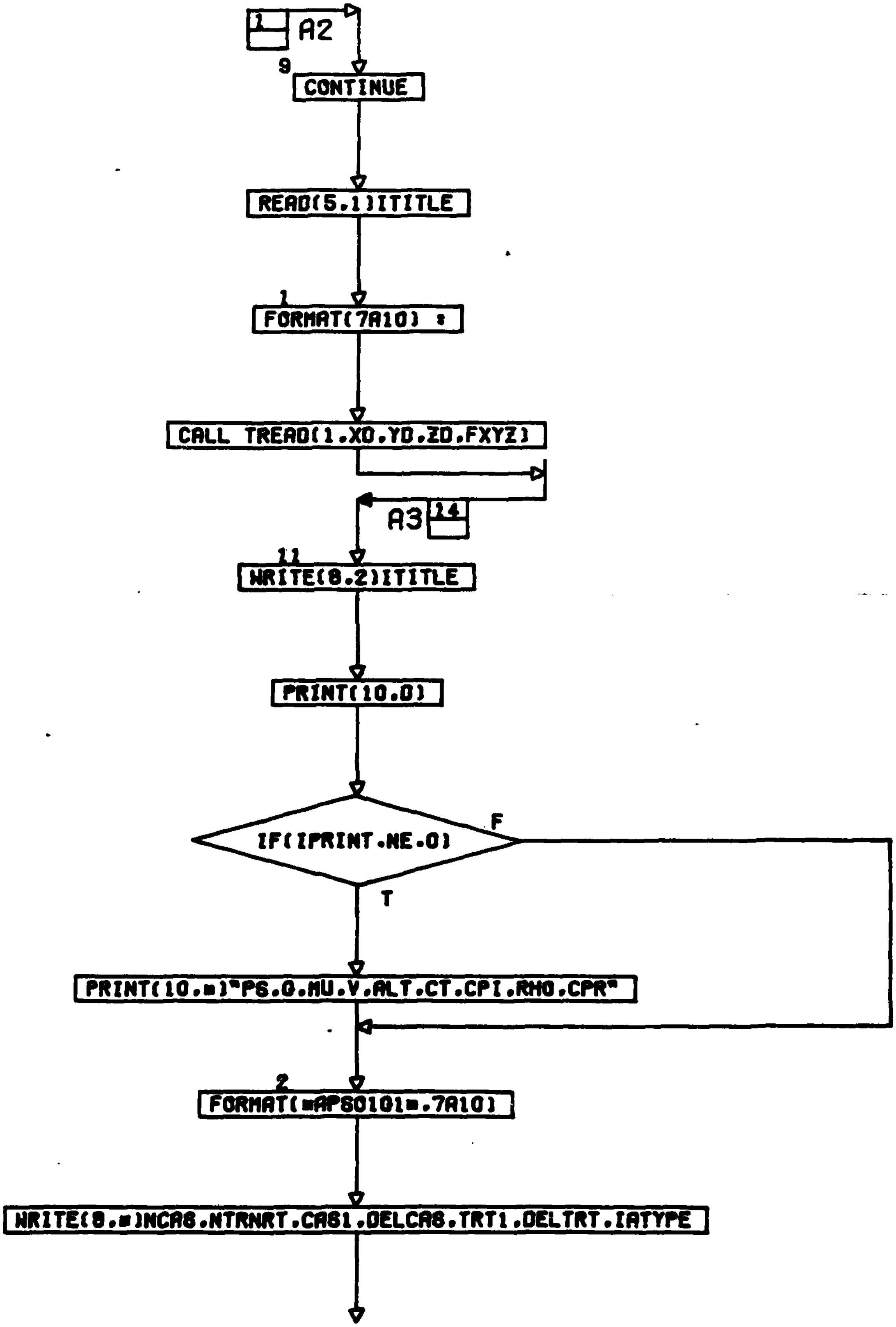
CONT. ON PG 11



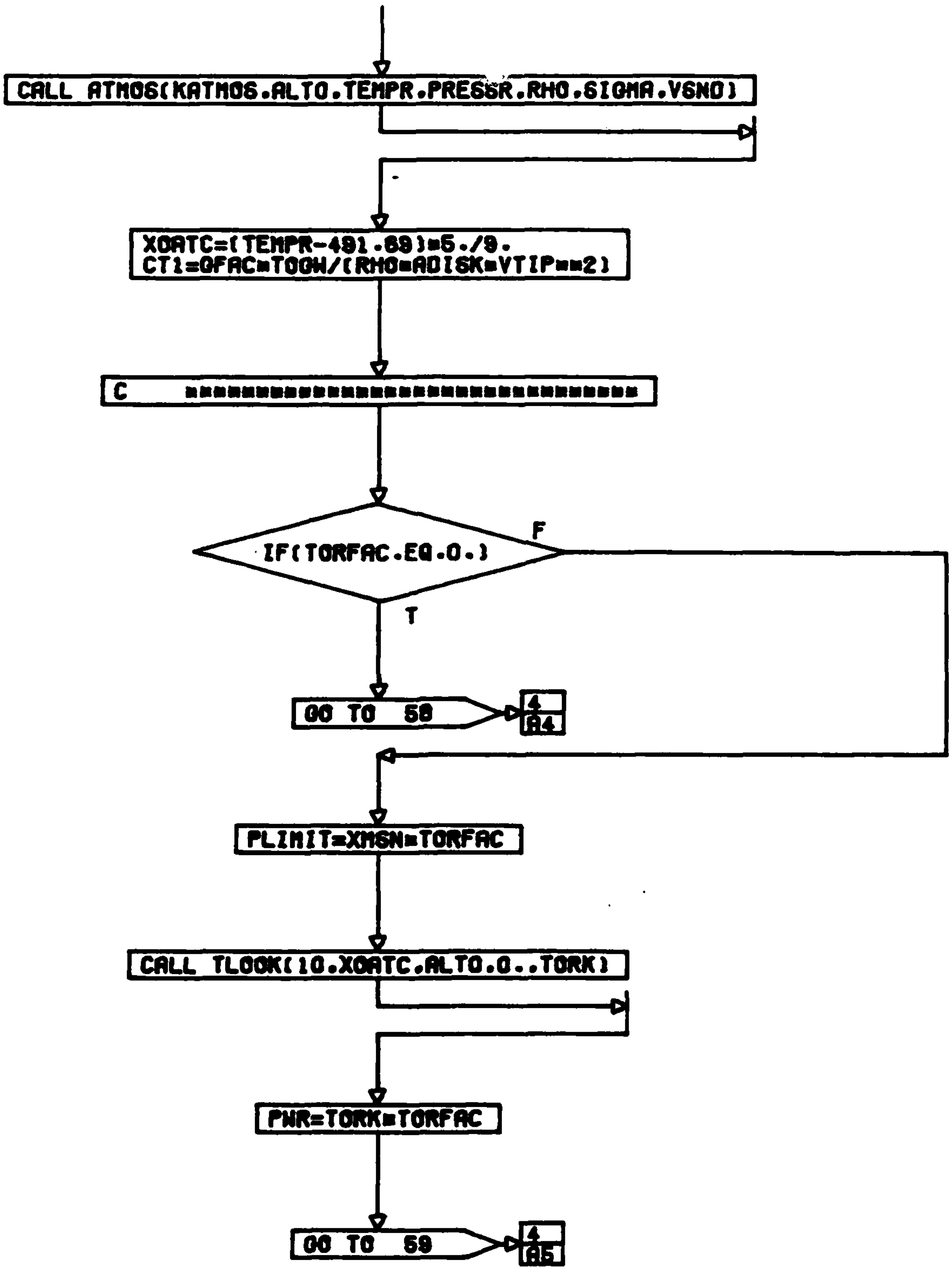
PG 11 FINAL


CMANEUV
PROGRAM MANEUV(INPUT.OUTPUT.TAPE5=INPUT.TAPE10.TAPE6.
TAPE8.TAPE9)
COMMON/PRINT/NPRINT
COMMON/IOUNITS/IP.IR.IO
DIMENSION PSS(75.75).XTAS(100).PSIDOT(100).TR(75).
V(100).ITITLE(7).XCAS(100).RAD(75.75).GFACT(75.75)
NAMELIST/D/NCAS.NALT.DELCAS.DELTALT.IATYPE.CPIRP.VTIP.UNV.
CAS1.ALT1.CTVAL.KATMOS.GFAC.TOGW.ADISK.TORFAC.PLIMIT.
ETAM.ETAP.DELFE.NPRINT.TMAN.TCHAR.MUCTSW.XMSN.IPRINT.
DELHP.CTMAX.TRVO.VB.ALTO.NTRNRT.DELTRT.TRT1
DATA IP.IR.IO/10.5.10/
DATA TORFAC.PLIMIT.TMAN.TCHAR.MUCTSW/0..1.E6.0..1..0/
DATA ETAM.ETAP.DELFE/1..1..0./
DATA XMSN.IPRINT.DELHP/100..0.0/
DATA G.NTRNRT.DELTRT.ALTO/32.1741.24..1..0./
DATA TRT1/.1/
READ(5.D)
IF(EOF(5))10.9
≠
0
2
A2
A1
14
10
STOP

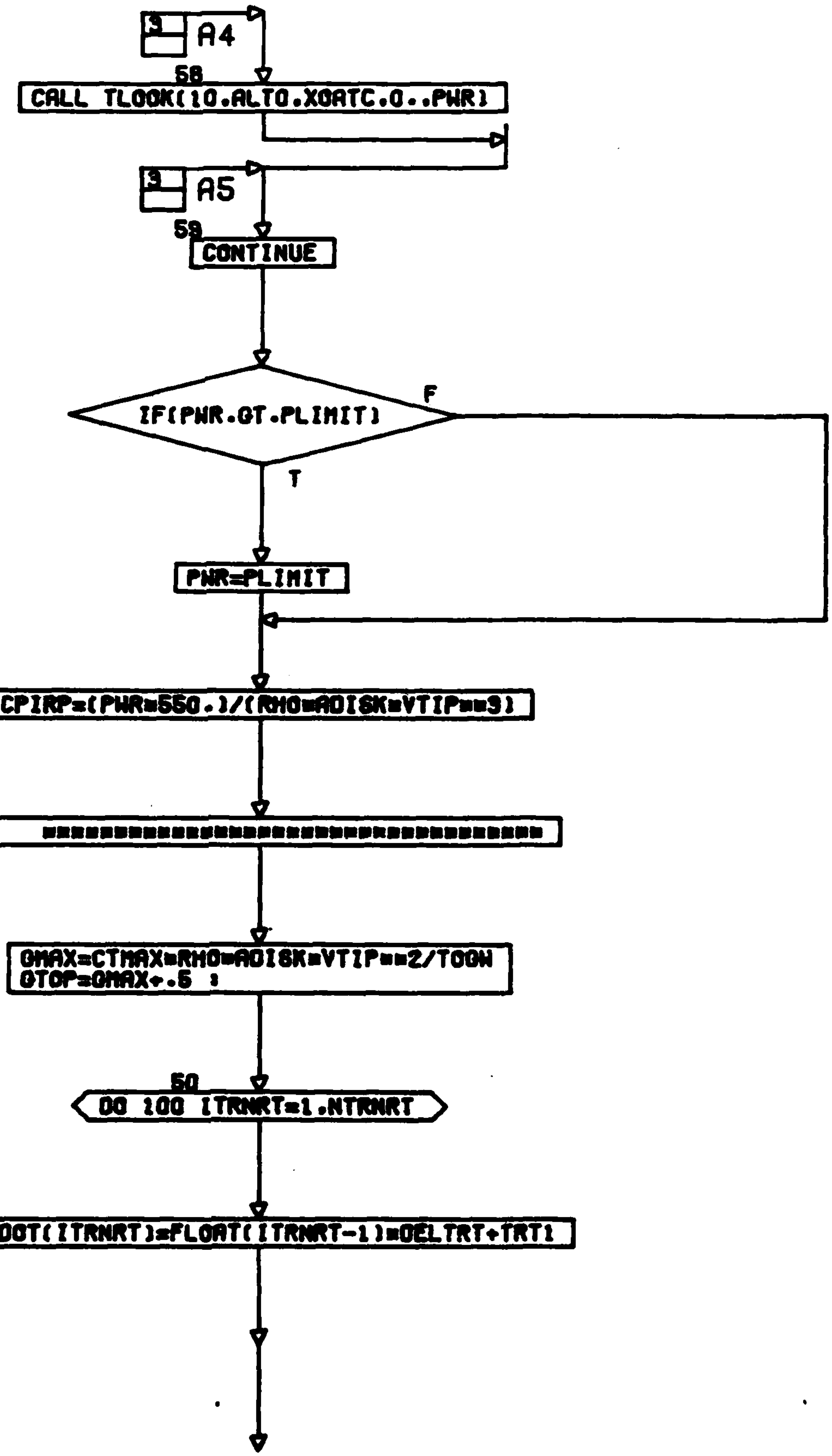
CONT. ON PG 2


1
A2
9
CONTINUE
READ(5,1)ITITLE
1
FORMAT(7A10) :
CALL TREAD(1,XO,YO,ZO,FXYZ)
A3
14
11
WRITE(8,2)ITITLE
PRINT(10,0)
IF(IPRINT.NE.0)
F
T
PRINT(10,*)"PS,Q,MU,V,ALT,CT,CPI,RHO,CPR"
2
FORMAT(*APS0101*,7A10)
WRITE(8,*)NCAS,NTRNRT,CAS1,DELCAS,TRT1,DELTRT,IATYPE

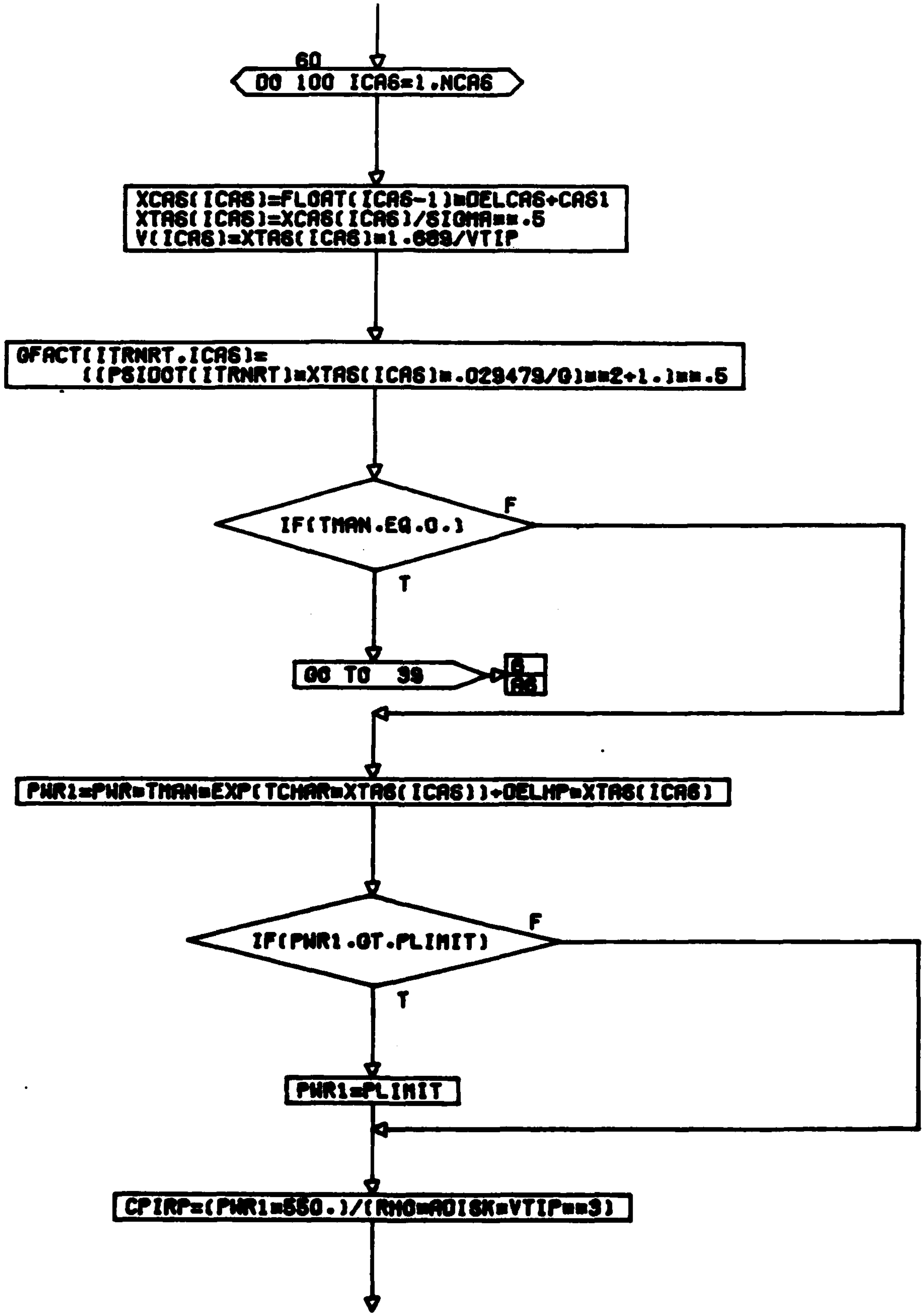
CONT. ON PG 3


CALL ATMOS(KATMOS.ALTO.TEMPR.PRESSR.RHO.SIGMA.VSNO)
XOATC=(TEMPR-491.69)*5./9.
CT1=GFAC*TOGW/(RHO*ADISK*VTIP**2)
C ********************************
IF(TORFAC.EQ.0.)
F
T
GO TO 58
4
A4
PLIMIT=XMSN*TORFAC
CALL TLOOK(10.XOATC.ALTO.0..TORK)
PWR=TORK*TORFAC
GO TO 59
4
A5

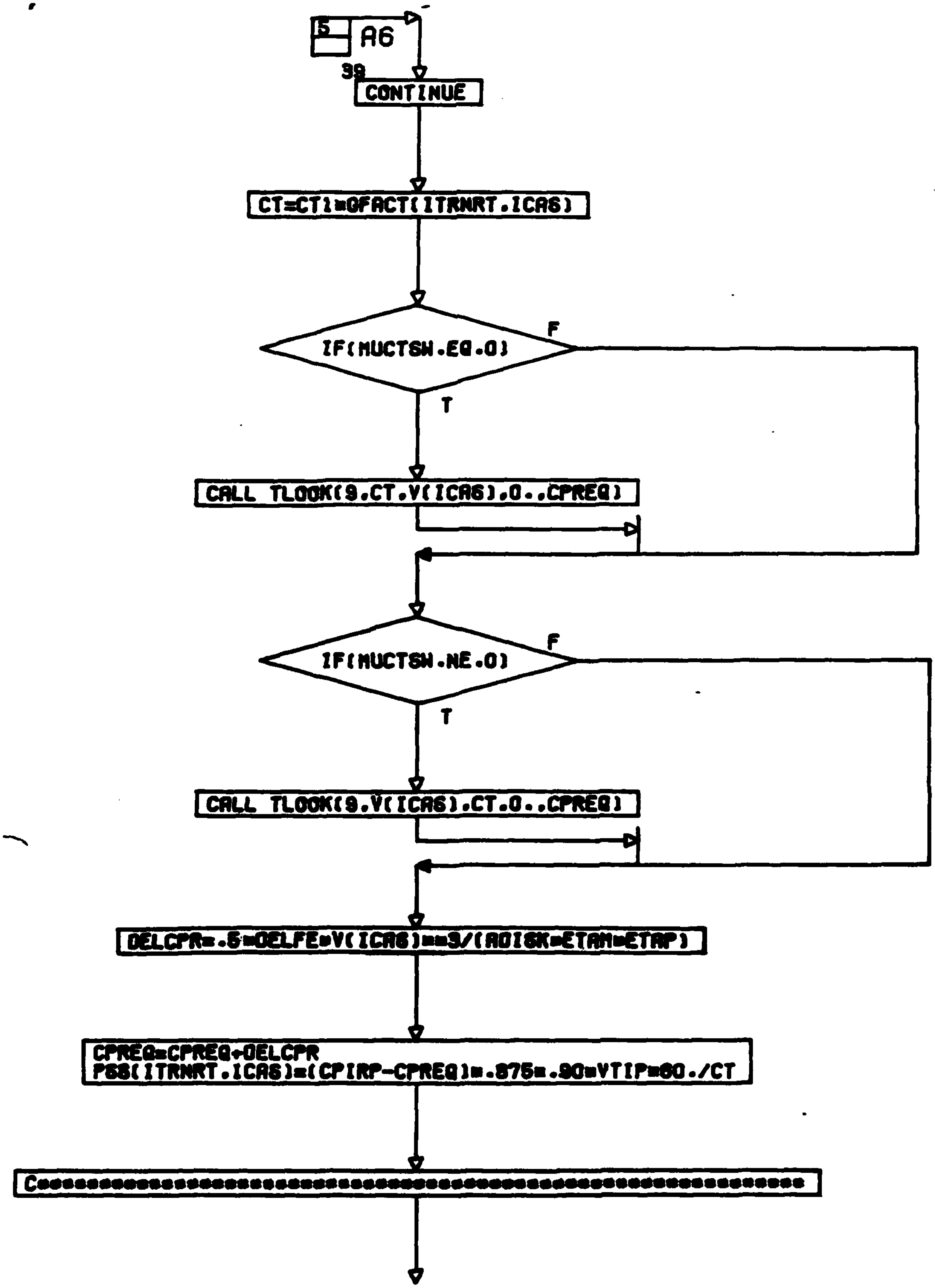
CONT. ON PG 4


A4
58
CALL TLOOK(10.ALT0.XOATC.0..PWR)
A5
59
CONTINUE
IF(PWR.GT.PLIMIT)
F
T
PWR=PLIMIT
CPIRP=(PWR*550.)/(RHO*ADISK*VTIP**3)
C ************************************
QMAX=CTMAX*RHO*ADISK*VTIP**2/TOGW
QTOP=QMAX*.5 ;
50
DO 100 ITRNRT=1.NTRNRT
PSIDOT(ITRNRT)=FLOAT(ITRNRT-1)*DELTRT+TRT1

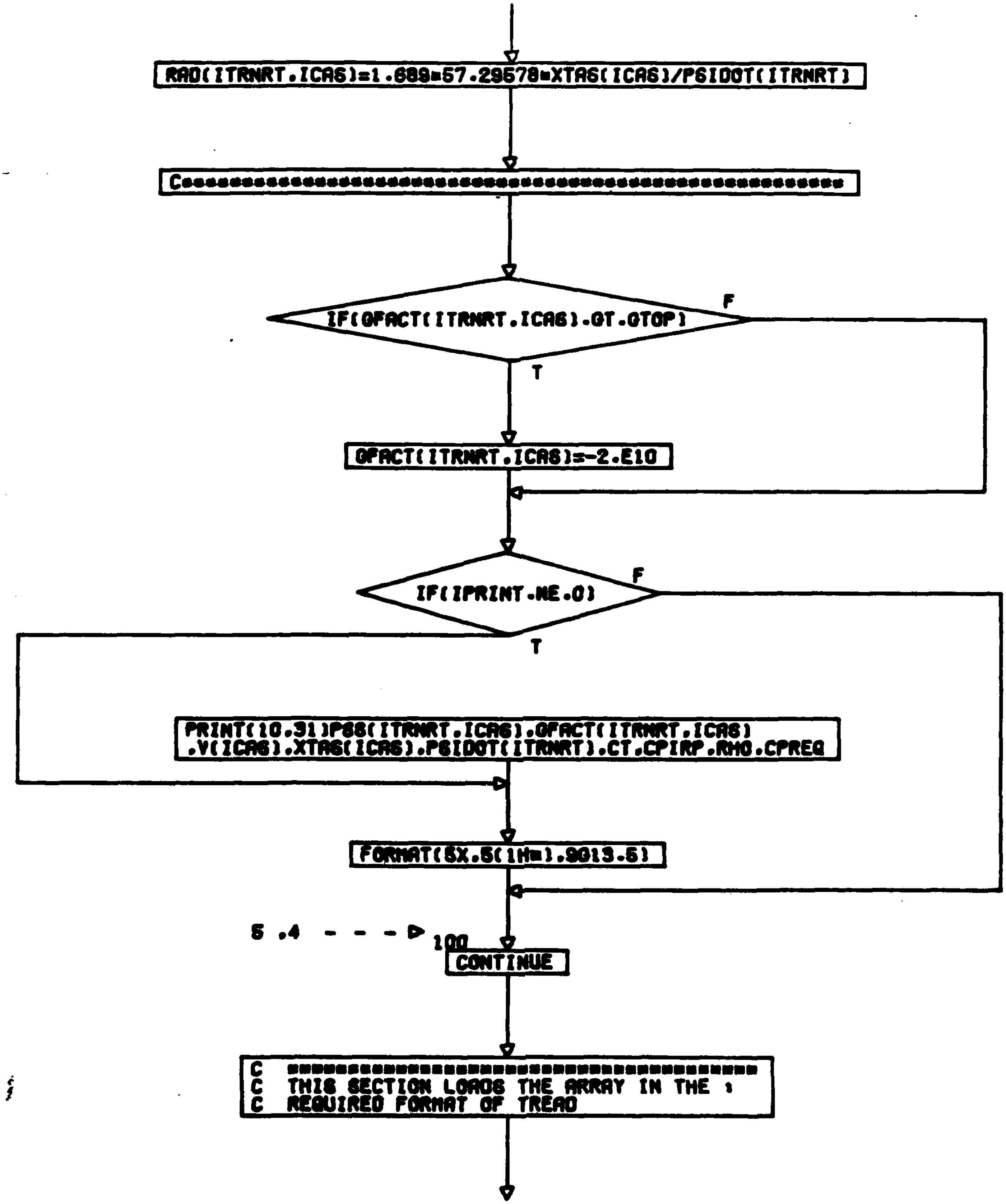
CONT. ON PG 5


60
DO 100 ICAS=1,NCAS
XCAS(ICAS)=FLOAT(ICAS-1)*DELCAS+CAS1
XTAS(ICAS)=XCAS(ICAS)/SIGMA**.5
V(ICAS)=XTAS(ICAS)*1.689/VTIP
GFACT(ITRNRT,ICAS)=
((PSIDOT(ITRNRT)*XTAS(ICAS)*.029479/G)**2+1.)**.5
IF(TMAN.EQ.0.)
F
T
GO TO 39
6
A6
PWR1=PWR*TMAN*EXP(TCHAR*XTAS(ICAS))+DELHP*XTAS(ICAS)
IF(PWR1.GT.PLIMIT)
F
T
PWR1=PLIMIT
CPIRP=(PWR1*550.)/(RHO*ADISK*VTIP**3)

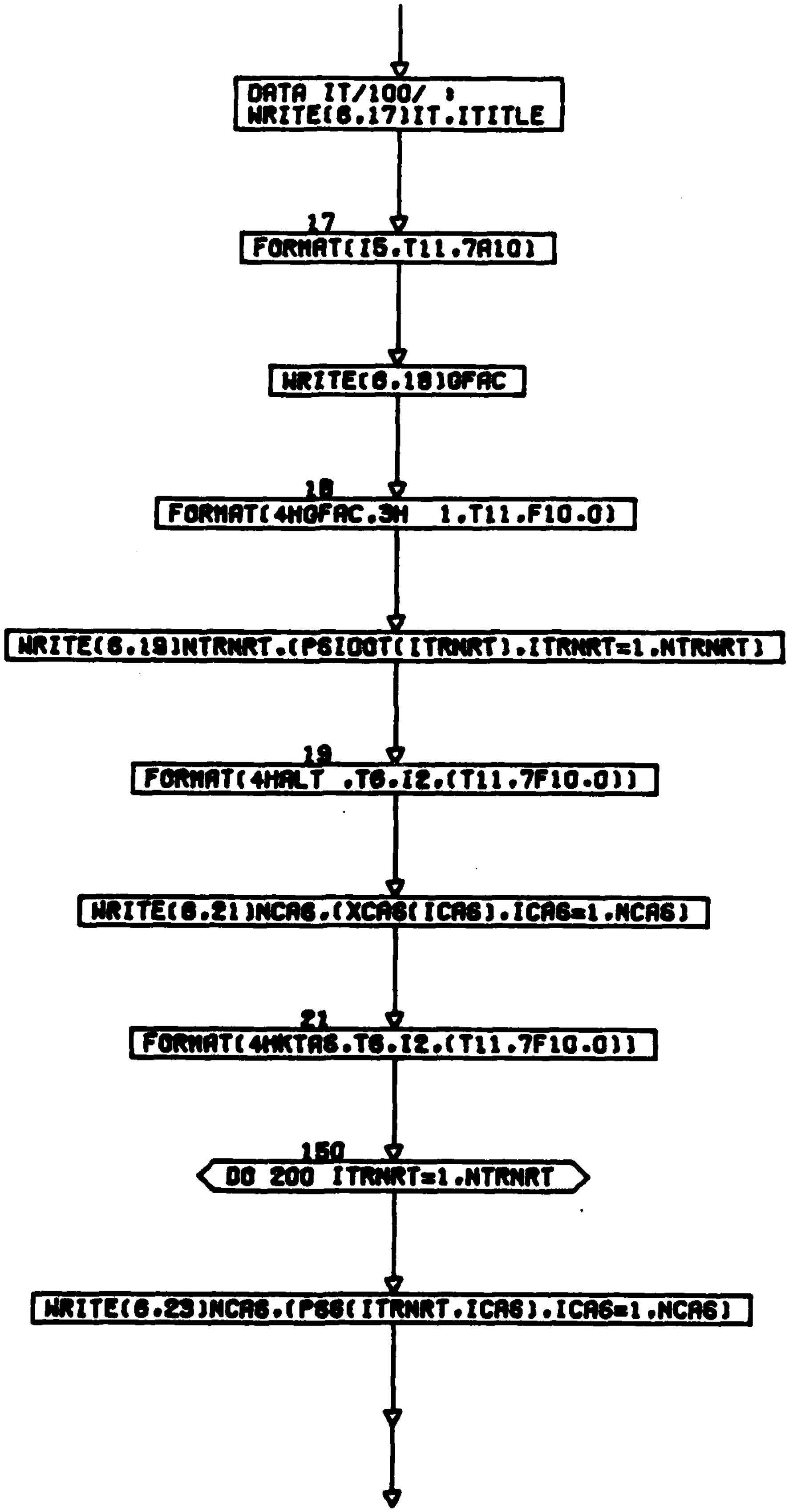
CONT. ON PG 6


5
A6
39
CONTINUE
CT=CT1*GFACT(ITRNRT,ICAS)
IF(MUCTSW.EQ.0)
F
T
CALL TLOOK(9,CT,V(ICAS),0.,CPREQ)
IF(MUCTSW.NE.0)
F
T
CALL TLOOK(9,V(ICAS),CT,0.,CPREQ)
DELCPR=.5*DELFE*V(ICAS)**3/(ADISK*ETAM*ETAP)
CPREQ=CPREQ+DELCPR
PSS(ITRNRT,ICAS)=(CPIRP-CPREQ)*.875*.90*VTIP*60./CT
C**

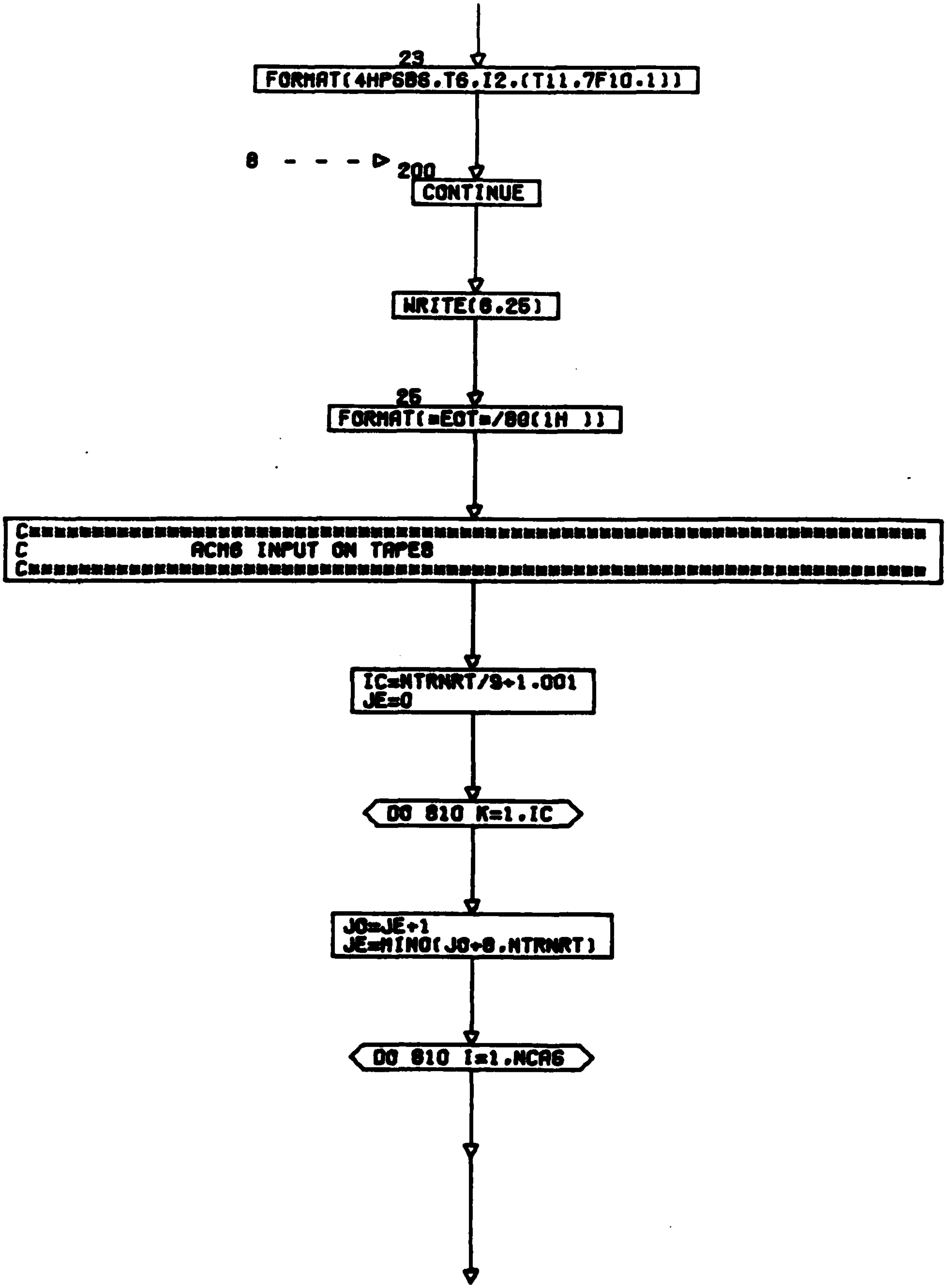
CONT. ON PG 7


RAD(ITRNRT,ICAS)=1.689*57.29578*XTAS(ICAS)/PSIDOT(ITRNRT)
C***
IF(GFACT(ITRNRT,ICAS).GT.GTOP)
F
T
GFACT(ITRNRT,ICAS)=-2.E10
IF(IPRINT.NE.0)
F
T
PRINT(10,31)PSS(ITRNRT,ICAS),GFACT(ITRNRT,ICAS)
,V(ICAS),XTAS(ICAS),PSIDOT(ITRNRT),CT,CPIRP,RHO,CPREQ
FORMAT(5X,5(1H*),9G13.5)
5 ,4
100
CONTINUE
C ************************************
C THIS SECTION LOADS THE ARRAY IN THE :
C REQUIRED FORMAT OF TREAD

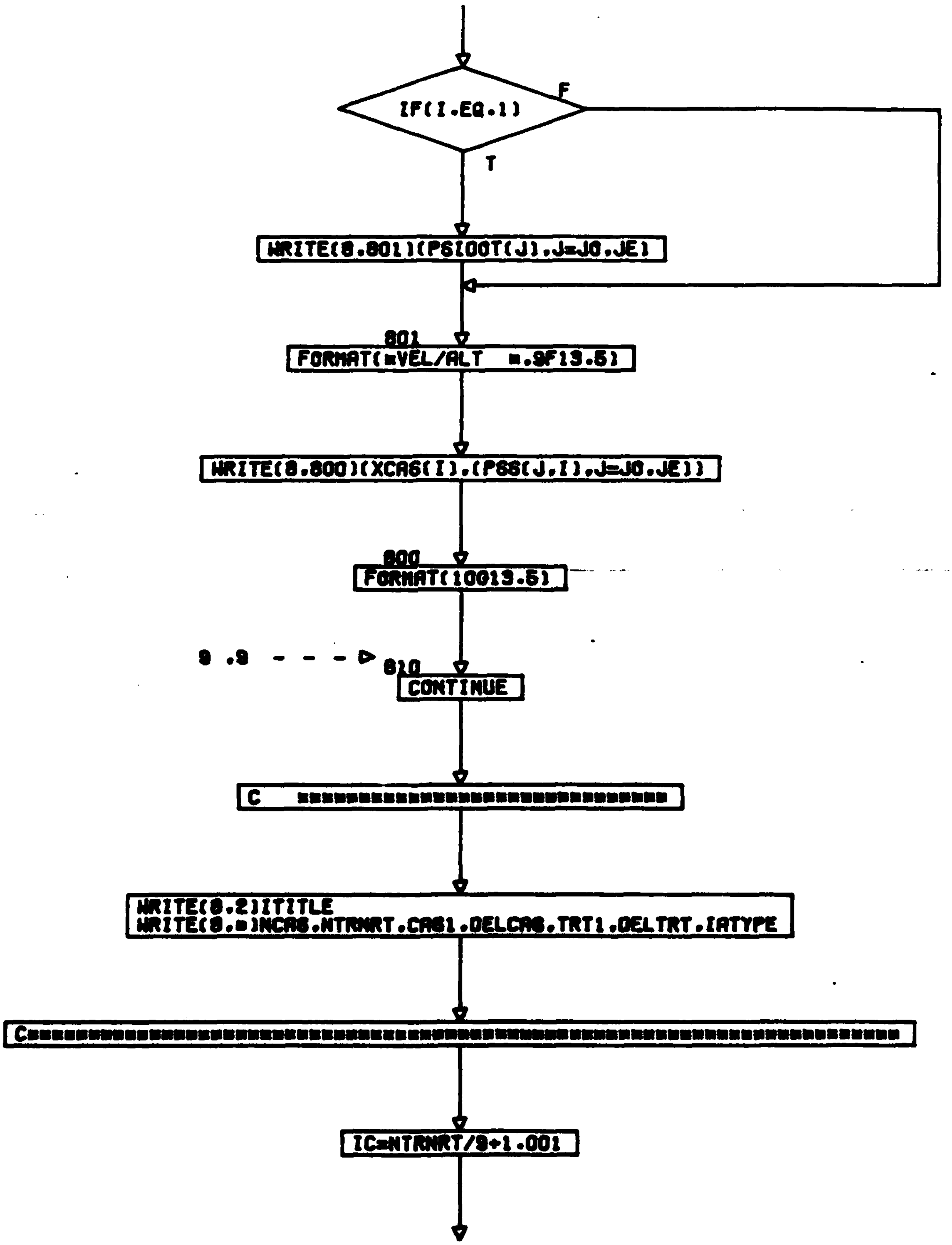
CONT. ON PG 8


DATA IT/100/ ;
WRITE(6,17)IT,ITITLE
17
FORMAT(I5,T11,7A10)
WRITE(6,18)GFAC
18
FORMAT(4HGFAC,3H   1,T11,F10.0)
WRITE(6,19)NTRNRT,(PSIDOT(ITRNRT),ITRNRT=1,NTRNRT)
19
FORMAT(4HALT ,T6,I2,(T11,7F10.0))
WRITE(6,21)NCAS,(XCAS(ICAS),ICAS=1,NCAS)
21
FORMAT(4HKTAS,T6,I2,(T11,7F10.0))
150
DO 200 ITRNRT=1,NTRNRT
WRITE(6,23)NCAS,(PSS(ITRNRT,ICAS),ICAS=1,NCAS)

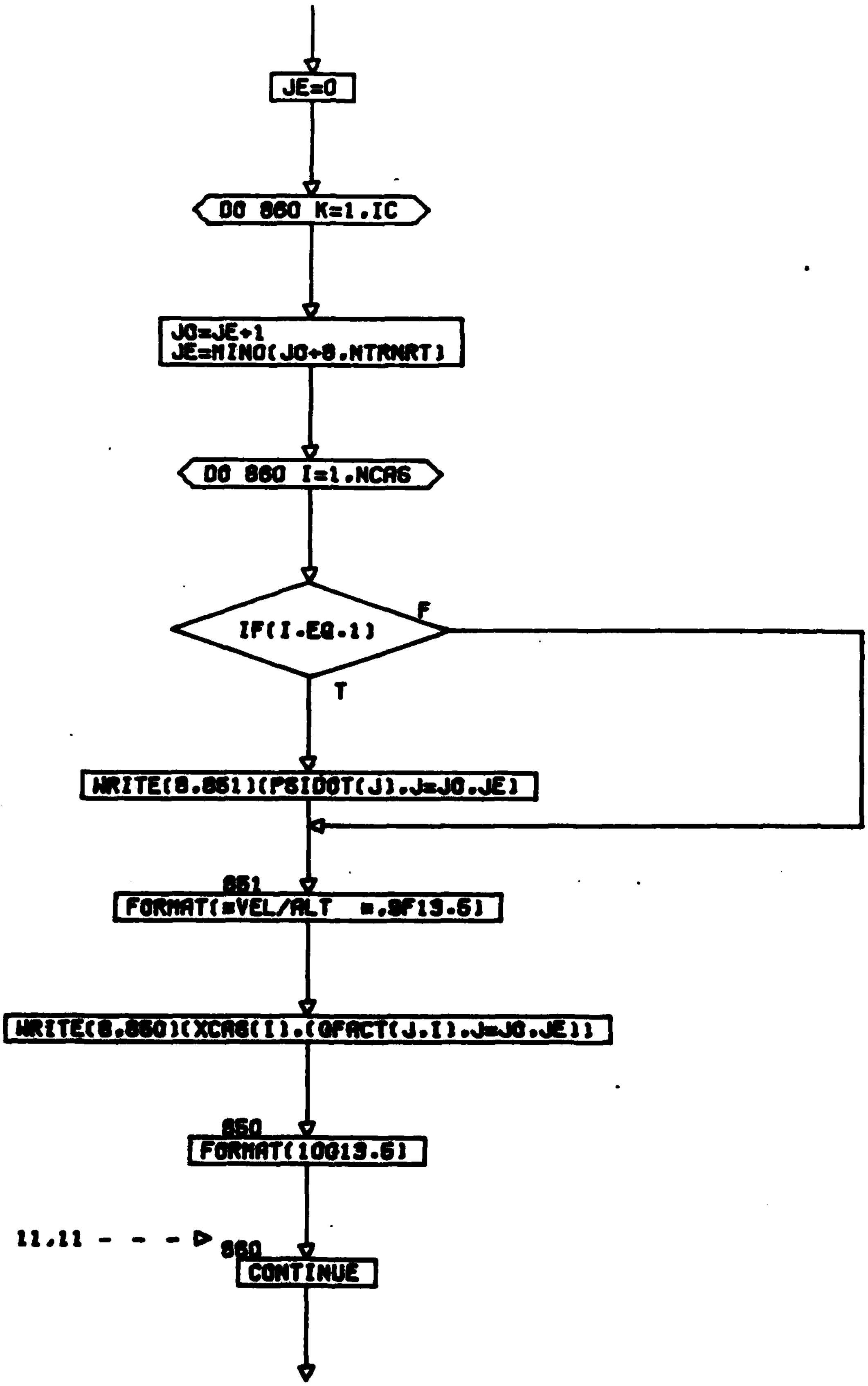
CONT. ON PG 9


23
FORMAT(4HPSBS.T6.I2.(T11.7F10.1))
8
200
CONTINUE
WRITE(6.25)
25
FORMAT(=EOT=/80(1H))
C===
C ACM6 INPUT ON TAPE8
C===
IC=NTRNRT/9+1.001
JE=0
DO 810 K=1.IC
JO=JE+1
JE=MIN0(JO+8.NTRNRT)
DO 810 I=1.NCA6

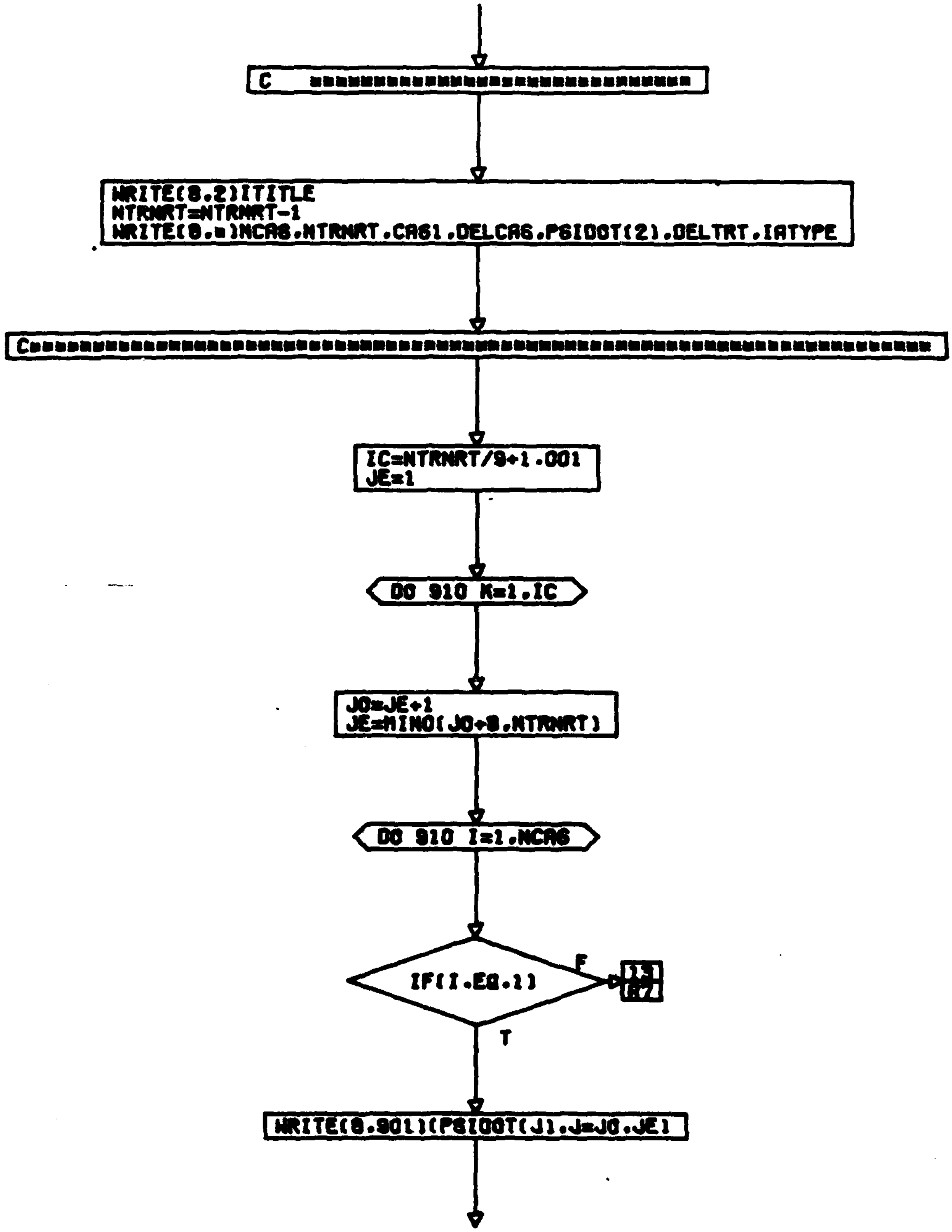
CONT. ON PG 10


IF(I.EQ.1)
F
T
WRITE(8,801)(PSIDOT(J),J=J0,JE)
801
FORMAT(=VEL/ALT =,9F13.5)
WRITE(8,800)(XCAS(I),(PSS(J,I),J=J0,JE))
800
FORMAT(10G13.5)
9 .9
810
CONTINUE
C ==============================
WRITE(8,2)ITITLE
WRITE(8,=)NCAS,NTRNRT,CAS1,DELCAS,TRT1,DELTRT,IATYPE
C==
IC=NTRNRT/9+1.001

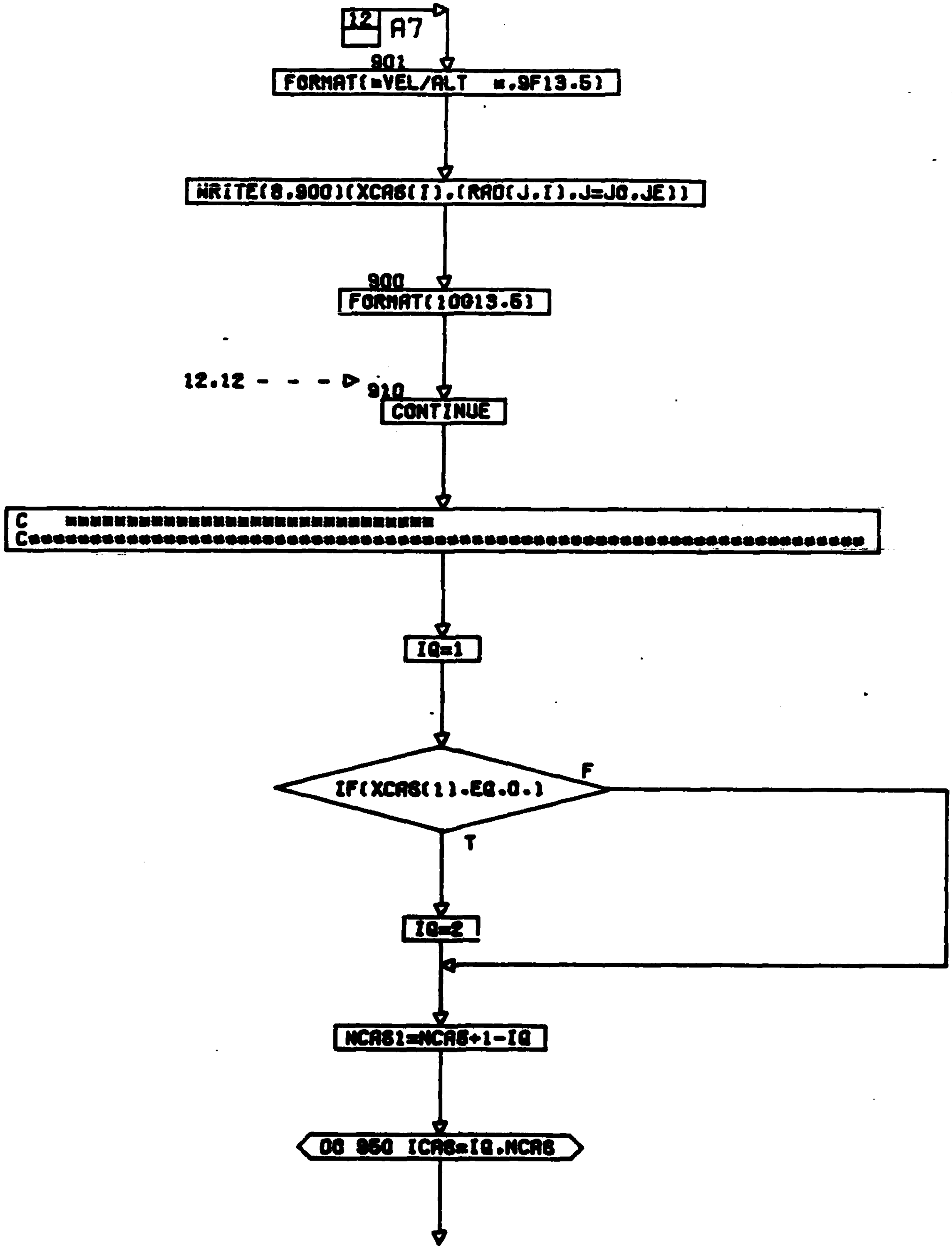
CONT. ON PG 11


JE=0
DO 860 K=1,IC
JO=JE+1
JE=MIN0(JO+8,NTRNRT)
DO 860 I=1,NCAS
IF(I.EQ.1)
F
T
WRITE(8,851)(PSIDOT(J),J=JO,JE)
851
FORMAT(*VEL/ALT *,9F13.5)
WRITE(8,850)(XCAS(I),(GFACT(J,I),J=JO,JE))
850
FORMAT(10G13.5)
11,11
860
CONTINUE

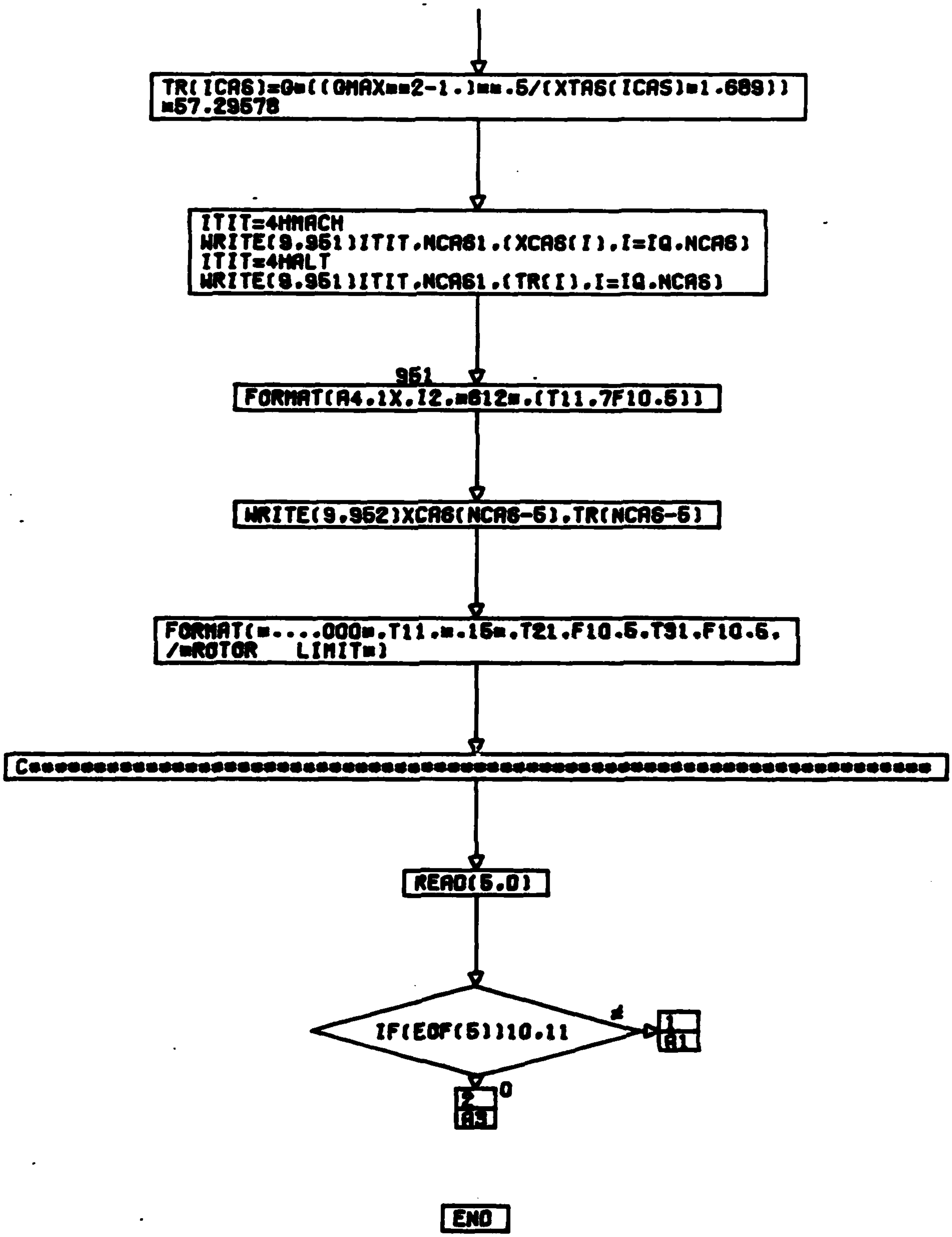
CONT. ON PG 12


C ******************************
WRITE(8,2)ITITLE
NTRNRT=NTRNRT-1
WRITE(8,*)NCAS,NTRNRT,CAS1,DELCAS,PSIDOT(2),DELTRT,IATYPE
C***
IC=NTRNRT/9+1.001
JE=1
DO 910 K=1,IC
JO=JE+1
JE=MIN0(JO+8,NTRNRT)
DO 910 I=1,NCAS
IF(I.EQ.1)
F
13
B7
T
WRITE(8,901)(PSIDOT(J),J=JO,JE)

CONT. ON PG 13


12
A7
901
FORMAT(=VEL/ALT =,9F13.5)
WRITE(8,900)(XCAS(I),(RAD(J,I),J=JO,JE))
900
FORMAT(10G13.5)
12.12
910
CONTINUE
C ==============================
C==
IQ=1
IF(XCAS(1).EQ.0.)
F
T
IQ=2
NCAS1=NCAS+1-IQ
DO 950 ICAS=IQ,NCAS

CONT. ON PG 14


TR(ICAS)=G*((GMAX**2-1.)**.5/(XTAS(ICAS)*1.689)) *57.29578
ITIT=4HMACH
WRITE(9,951)ITIT,NCAS1,(XCAS(I),I=IQ,NCAS)
ITIT=4HALT
WRITE(9,951)ITIT,NCAS1,(TR(I),I=IQ,NCAS)
951
FORMAT(A4,1X,I2,*612*,(T11,7F10.5))
WRITE(9,952)XCAS(NCAS-5),TR(NCAS-5)
FORMAT(*....000*,T11,*.15*,T21,F10.5,T31,F10.5, /*ROTOR LIMIT*)
C***
READ(5,0)
IF(EOF(5))10,11
≠
1
A1
0
2
A3
END

PG 14 FINAL

END